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ABSTRACT

Presented is the annual report for Resources for the Future, Inc. (RFF) for the year ending September 30, 1973. This organization is dedicated to advancing the development, conservation, and use of natural resources and the improvement of the quality of the environment through programs of research and education. Most of their studies are in the field of the social sciences. Document content includes an essay by the group's president, Joseph L. Fisher, entitled "Keeping Things in Perspective," and two special articles, "Air Pollution and Human Health" and "Low-Cost, Abundant Energy: Paradise Lost?" both by RFF members. Educational and research programs conducted in the following areas are described: quality of the environment, natural environments, land and water resources, energy and minerals, regional and urban studies, appraisals and special projects and Latin American Programs. A list of RFF publications, staff activities and writings, and a financial statement are also reported. (BT)

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RESOURCES FOR THE FUTURE

Annual Report

for the year ending September 30, 1973

1755 Massachusetts Avenue, N.W., Washington, D.C. 20036

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Resources for the Future, Inc. is a nonprofit tax-exempt corporation chartered under the laws of the state of New York, with headquarters in Washington, D.C. It was established in October 1952 with the cooperation of the Ford Foundation. Its purpose is to advance the development, conservation, and use of natural resources and the improvement of the quality of the environment through programs of research and education. Some of its programs are carried out by the resident staff; some are supported by grants to universities and other nonprofit organizations. Most of its studies are in the field of the social sciences.

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THE PRESIDENT'S ESSAY

Keeping Things in Perspective

by Joseph L. Fisher

It is not easy to keep things in perspective at any time; the series of crises to which this country and the world have been subjected during recent months and years has made it even more difficult for people to maintain a balanced view of what has been happening and what lies ahead. But this is exactly what each person must try to do: to see things steadily and to see them whole with each one endeavoring to find his own most satisfying and socially constructive role.

Ours seems to be a time of crises. The last few years have seen the youth crisis, the population crisis, the Southeast Asia and the Middle East crises, the inflation crisis, the dollar crisis, the environmental crisis, and the crisis of confidence, along with several others. We in this country have been moving from crisis to crisis with hardly a breather. One of them ends, not so much by a solution as by the beginning of another. Americans are on a roller coaster, going up and down from manic highs to depressive lows. The nearly instantaneous reporting of the modern media of communications now makes it possible for almost everyone to be on the same roller coaster.

■ For the last few months it has been the energy crisis that has absorbed the attention of the American people and the people of Western Europe, Japan, and the Middle East as well. Like most crises, this one, at least for the United States, was brought on by a combination of long-term trends and short-term events. It has been clear for some years that the difficulties and costs of finding and extracting more oil and gas from sources within the United States were increasing. For several years it has also been clear that the major petroleum exporting countries, especially in the Middle East and North Africa but also in other places, were going to drive harder bargains for their products. The need in the United States for greater protection from environmental damages caused by the tremendous growth in the production and consumption of energy led, in the last several years, to the imposition of restraints and controls which added to the cost of energy and to growing public resistance to locating and constructing new refining and other con-

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version facilities. These and other problems of increasing energy supplies have been placed in the setting of continuing rapid growth in demand, which has been running at over 5 percent for oil during the last four years, around 4 percent for natural gas, and over 6 percent on average for electricity. Behind these increases on the demand side lie the powerful pressures of population growth, rising incomes, devotion to the automotive way of life, expanding air travel, continued displacement of railroads by trucks for hauling freight, rapid extension of air conditioning in houses and structures of all kinds, further electrification of homes and offices, and so on.

In short, the inexorably rising curve of demand broke through and outdistanced the sluggish and relatively stable curve of supply; the impending gap between the two has been clearly visible for several years. To fill the gap Americans have been relying on imports of oil and oil products, principally from Canada and Venezuela, but increasingly from the Middle East and North Africa, where reserves are very large and production costs still exceedingly low. The sudden outbreak of war between Israel and the Arab countries in October 1973, followed by the embargo on shipments of oil to the United States, has driven the nail home; Americans are facing a genuine energy crisis now.

■ The energy crisis is not the first crisis of natural resources faced by the United States in the twenty-five years since the end of the Second World War. Immediately following that war it was widely held that there would not be enough raw materials of various kinds for the restoration of the badly damaged European and Japanese industrial economies, or even for the rapid conversion of the United States economy to a peacetime basis. Awareness of a possible running out of resources was widespread in this country, as evidenced by Fairfield Osborne's remarkable book, *Our Plundered Planet*. (Incidentally, Osborne was one of the founding fathers of Resources for the Future.)

In the early 1950s there was widespread concern about a possible shortage of adequate supplies of fresh water in several important regions of the United States. A presidential commission investigated the subject and reported its findings. One response was the establishment of a federally aided water resources research program with units in the various land grant universities of the country. The water crisis has ebbed and flowed down to the present time; within the last year another distinguished government commission has completed its report on the subject. (Again incidentally, a member of the RFF Board of Directors headed this second commission and another member took a leading part in the work of the earlier commission.) In the early 1950s also the National Materials Policy Commission, headed by a former chairman of Resources for the Future, addressed the problem of supply difficulties and rising costs of mineral products. Last year another

national commission reported on the same subject, emphasizing the need for conservation and recycling of materials.

More recently, within the past several years, awareness of an environmental crisis has gripped the country. Ecology has passed from the status of an arcane science to a household word. The cutting edge of the environmental movement has been the fight for antipollution laws, principally at the federal level but also at the state and local levels. These have included acts dealing with clean air and clean water, solid waste disposal, the use of pesticides in agriculture, the discharge of radioactive substances as well as toxic metals and other materials, and so on. Of most general importance was the passage several years ago of the National Environmental Policy Act, which established the Council on Environmental Quality and required the preparation of environmental impact statements by government agencies proposing projects or programs that would have significant effects on the environment. The courts have been important to the environmental movement in various ways; for example, by permitting class action suits to be brought by individuals and groups whose mission has been to defend the environment against government agencies and others who, they thought, were about to engage in actions potentially damaging to the environment. Supporting the environmentalists have been a variety of other organizations and groups, such as those concerned with stopping population growth, reducing economic growth, and preserving natural areas, among others. The environmental revolution, so-called, has been one of the significant features of the social and political history of this country from the late 1960s up to the present time. Now it is confronted by the energy crisis, the alleviation of which may well require what a confirmed environmentalist would regard as retrogression — reducing standards for air and water quality, landscape, and urban conditions or postponing their achievement.

■ The fact is, of course, that resource and environmental difficulties are likely, now and for the future as far as one can see, to be widespread, interrelated, and more and more intractable. Turner said that the passing of the American geographic frontier took place about 1880 and with its passing there set in the beginnings of a profound change in the American character and view of life. A good case can be made that, in about 1970, a kind of resource frontier, viewed on a world scale, ceased to exist as increasing numbers of people in the various countries became aware of the planetary constraints of spaceship earth. This is not to say that a general collapse is all but inevitable within the next hundred years or so, which seems to be the implication of the remarkable book, *Limits to Growth*, published a few years ago, but it does portend dire results some time in the future unless the people of this planet can succeed in coming to environmentally acceptable terms with the resources and resource potentials of their finite world. Largely

this means coming to terms with population growth and with technological and economic growth as well. Programs to achieve population stability in a noncoercive way are called for. A careful economic and social assessment of new technology is required before it is installed. And economic growth must be reformed and redirected along lines that will be socially and environmentally acceptable over the long run.

■ It is proper to ask some basic questions. What gives rise to these resource crises? How can they be foreseen? What actions will be helpful in countering their effects? These crises seem to share the following qualities: the observed conditions — water supply, environment, energy — are unsatisfactory; there is an awareness that a continuation of past trends will lead to severe difficulty or even disaster; no easy way out of the difficulty is at hand; not only do leaders see the problem, but the gut reaction of large numbers of people testifies to the problem also; the shortage or other crisis comes to be regarded as an imminent threat to something held dear by many people (not enough water, the loss of discretionary use of the automobile, or the destruction of some precious element in the natural environment). In the typical crisis situation, as I have been using the term, people generally think that something can actually be done to correct, or at least ease, the difficulty; that is, there is enough knowledge, technology, management, and money to make things better. As always, the principal obstacles are perceived to be not so much in the nature of resources and things as in the nature of people and their institutions. This is perfectly sound because it is through technological advance, better management, more careful conservation, and new policies and organizations that needed changes are achieved. The fault lies not in our stars, but in ourselves.

Coping with the energy crisis or any other is made even more difficult because one crisis tends to be overlaid by several others. Thus, the energy crisis and the environmental crisis, obviously closely related, are connected also with the transportation crisis, various crises of urban living, and, in a general sense, the population crisis. Not only two crises but perhaps half a dozen are rolled into one, each affecting and being affected by the others. Let me consider here in a little more detail only the ones labeled energy and environmental.

■ The energy crisis comes in three dimensions: short, middle and long range. In the first category is the immediately threatened shortage of heating fuel and gasoline. Short range also, one hopes, is the embargo on oil shipments to the United States from the Arab countries of the Middle East and North Africa. To increase supply in the short run is difficult. Developing new sources — offshore, Alaskan, liquid or gaseous fuel from coal or shale, nuclear — takes time. Reducing consumption, or rerouting it toward more plentiful fuels, also takes time — except under the pressure

of crisis, such as now is upon us, when demands can be checked by allocation and rationing schemes. Allowing prices of oil products and other fuels to go up — the normal response to shortage in the face of rising demand — runs counter to government efforts to dampen inflation, which everyone wants done, and works a particular hardship on poor people who have to use their cars to go to work and for other essential purposes. Even so, prices of gasoline and other oil products will undoubtedly continue to go up, but probably not enough to correct the supply–demand imbalance. In the short range, the outlook is for trouble and the possibilities for corrective action are strictly limited. (Observations regarding the short-range aspects of a crisis obviously are easily outdated: who knows precisely what will happen next week or next month?)

Furthermore, the enormous windfall gains that can accrue to oil companies from sales of domestic oil as a result of the general shortage and especially of the rapid escalation of the price of imported oil pose a severe dilemma: higher profits encourage exploration, discovery, and development of new sources; they are needed but are unacceptable as a matter of social equity at a time when all others are having to make sacrifices. A workable compromise would consist of a moderate, controlled price rise plus an excise tax to assure that undue profits would go to the government to serve public purpose such as, for example, increased research and development on new, clean energy sources and conversion technology. The need for special tax treatment of oil such as the depletion allowance and other expensing privileges seems to have passed with the advent of higher product prices.

For the middle range, the outlook is mixed, uncertain, iffy, but with more room to maneuver. Over the next five to ten years, or perhaps even longer, if events break reasonably well, enough oil and other energy commodities could become available to meet, if not the typical 4 percent annual increase in consumption, at least a more modest 1 or 2 percent growth. A step-up of offshore leasing, drilling, and development could occur, as well as some increase in onshore production from new wells, plus secondary or even tertiary recovery from existing wells. North Slope Alaska oil could be in full production toward the end of the 1970s. Given some kind of resolution of the Mideast conflict, imports could be increased from the very large reserves of oil there, but at no bargain, given the economic muscle the exporting countries are willing to use. In addition, timely actions now might mean at least a beginning of liquid fuel production from coal and shale. There could also be much more electric power from conventional reactors, or from breeder reactors after, say, 1985.

But each of these possibilities carries with it a burden of environmental consequences. Offshore oil presents threats of ocean and shoreline pollution. The Alaska pipeline has been a classic confrontation of developers versus environmentalists. More imports

will require port facilities, onshore or offshore, for handling supertankers, which also presents pollution dangers. Strip-mining of coal or shale requires the removal of vast quantities of overburden and the consequent scarring of the landscape. And nuclear power entails the possibility, however remote, of incalculable damages from the escape of long-lived radioactive substances. In each case the increase in energy production will have to be weighed against the increased damage or threat of damage to the environment. Thus the energy crisis intensifies the environmental crisis, especially if environmental standards have to give way to the need for energy that is more polluting.

For the long range of twenty or more years ahead, additional supply options come into view: geothermal heat, solar energy, nuclear fusion, and truly large amounts of liquid products from coal, shale, and tar sands. These, too, present us with environmental problems but with more time to figure out how to handle them. Furthermore, in the perspective of a decade or more, entirely new technology, products, and even consumption patterns can change the whole picture.

■ Will the energy crisis completely eclipse concern for ecology? The environmental crisis has been with us now for several years, and it has many manifestations: foul air over most of our cities much of the time, sewage- and silt-laden streams, monumental amounts of solid waste to dispose of, toxic chemicals in both air and water, heat, noise, congestion, and general disfigurement and disruption of the urban and rural landscape. Gains have been made, of course. Very few Americans die nowadays from cholera or typhoid. Water is potable nearly everywhere and food is pure enough to eat safely. People live longer than they used to. But the discharge of wastes, some of it poisonous, is now so large and so diffused over wide areas, and so difficult to cope with, that crisis is not too strong a word to characterize the situation. Added to this have been the rising expectations people have regarding a clean, healthful, and attractive environment. Convinced that the technology, managerial capability, and funds are available for improving the environment, they want results.

In a crisis situation when things are not going well at all, Americans tend to look for the villains who got us into the mess. In turn, the environmental crisis has been blamed on big business, bureaucratic government, the media, technology, and the establishment, whatever it is. The true causes, however, are deeply embedded in the whole structure and functioning of society and the way individuals behave. The increase in population, especially in urban areas; the growth of industry, particularly polluting industry; the rapid approach toward the limits of air, water, and land to absorb, hide, dilute, or flush away the increasing load of pollutants; the reluctance of people virtually everywhere to reduce their consumption, change their littering habits, or pay the clean-up bills—

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these are among the principal causes of environmental deterioration.

The main lines of solution fortunately are becoming clearer as the problems get worse and more and more people clamor for action. (1) Set strict but attainable standards for air and water conditions and then enforce them. (2) Where possible, levy charges on polluters according to the damages they cause, in the hope that they will then refrain from polluting so as to avoid the charges. (3) Provide technical aid and financial inducements for the reclamation and recycling of waste materials. (4) Make sure that costs of preventing or repairing damages caused by polluting products are somehow included in their prices. (5) Always lean in the direction of raw materials, industrial processes and products, and consumption habits that are less polluting. (6) Install new institutions, frequently regional in scope, to plan and administer the necessary preventive and corrective programs.

The costs of a vigorous program of environmental improvement do not appear to be unbearable: 2 to 2½ percent annually of the gross national product ($24 to $30 billion a year this year), about twice what is now being spent, would enable good progress to be made.

If we look far ahead to the end of this century and beyond, it is clear that continued population and economic growth will ultimately overtax both the capacity of the environment to absorb pollutants and its capacity to provide raw materials including those that yield energy. Technology and general cleverness promise only to stave off the Malthusian day of reckoning, but they can buy us precious time to figure out better ways of handling things and to make appropriate adjustments in our whole style of living, the arrangements of our cities and towns, our aspirations, and our culture generally.

■ The environmental crisis and the energy crisis tend to overlap and merge. Most air pollution is due to the burning of hydrocarbon fuels, principally in automobiles and other vehicles which also cause noise and congestion in our cities. Oil is the largest polluter of oceans and shorelines, coal mining the greatest disfigurer of the landscape. An excess of carbon dioxide in the upper atmosphere, if that should turn out to be a problem; ecologically unbalancing amounts of heat in major metropolitan air sheds; the risk of radioactive catastrophe; the production of large amounts of potentially contaminating chemicals, such as those contained in fertilizers and pesticides—all of these are based on or closely linked to energy.

Ironically, many promising solutions to each of these crises, or both taken together, will require yet more technology that consumes energy and thereby adds to pollution of some sort. Again, the search must be for technology, such as ways of reducing the emission of pollutants from vehicles, whose net effect, including all the side effects on the environment and on people's health and welfare, is favorable and which, on balance, will require less energy.

■ Over the years Resources for the Future has tried to maintain a steady, balanced, systematic view of the various crises pertaining to resources and the environment that have paraded across the American scene. We have tried, through disciplined research, to understand the factors involved and the interrelationships among them. Always we have valued objectivity most highly, being aware that most organizations concerned with these matters have been advocates of one position or another. Thus, on many occasions our researchers have had to resist the temptation to rush to the barricades in defense of a cause, however laudable the cause. Before a situation became a crisis RFF has seemed to be looking at it with undue alarm; for example, water and air pollution five years or so before the public became concerned. After a crisis has been widely perceived as such, RFF has been criticized for being too complacent, of not being with it, of turning its attention elsewhere, frequently to a problem destined to become a crisis several years later.

At all times, we have wanted to maintain credibility with all parties to the numerous conflicts that have occurred. This does not mean we have been uninterested in policy and action; rather, it means that we have sought to make our contribution by defining issues, analyzing the factors involved, appraising alternative policies in terms of the objectives and standards they seek to achieve, examining the feasibility of other objectives altogether, and, of course, reporting our conclusions in a straightforward and timely way. There is a place for advocacy study, but we have striven for objective research, and that has been enough to keep us fully occupied.

From its beginning twenty years ago, but increasingly during the past year or so, Resources for the Future has been concerned with policy outcomes and has selected research projects whose findings could be of use to the policy makers in government and in the private sector. During the past year, for example, we have completed a report on Alaskan oil in which the advantages and disadvantages of the Alaska pipeline project were laid bare, two studies on urban land policy with numerous direct policy implications, a legal analysis of the National Environmental Policy Act, plus a number of other reports with direct bearing on what to do about the various crises being considered here. In all of these studies particular attention has been given to the legal, institutional, organizational, technological, and behavioral issues that could be dealt with through changes in policy at various government and private levels.

Our strategy in choosing research projects has been along two lines. First is the broad and systematic examination of resource and environmental trends and problems. Thus we have tried to keep under more or less continuous surveillance such subjects as energy supplies, environmental pollution, land use and management, and water resource problems. Second, we have tried to select

for examination those particular problems which we thought to be critical in the sense that, without solution, progress of a more general kind would be held up. The first, more comprehensive research has embraced theoretical, statistical, historical, and methodological work. The second has included applied analysis, case studies, policy background reports, and collections of professional papers on particular subjects.

Throughout its two decades of experience, RFF has striven to help keep things in perspective by seeing them clearly, steadily, and objectively. Such a view seems more needed now than ever as the number of crises multiply and people seek solutions on which they can depend to meet not only immediate problems of tomorrow, but also the problems of the long years ahead.

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TWO SPECIAL ARTICLES

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Air Pollution and Human Health

The recent collision of U.S. air quality standards with U.S. energy policies has placed a premium on the knowledge our scientific community possesses, or can acquire, about the effects that air pollution may have on human health. The current problem is more than one of balancing the benefits to polluters from venting residuals into the atmosphere against the damage suffered by society as a result of the increased pollution. From a policy-making standpoint, the basic difficulty is our ignorance. We are uncertain who suffers, to what degree, from what amount of which agents. Under an RFF grant, Lester B. Lave of Carnegie-Mellon University and Eugene P. Seskin of the Urban Institute have been engaged in research addressed to that chain of questions. The following essay is adapted from their recently completed interim report.

It is misleading to speak of air pollution as if a single substance were involved. Sulfur oxides, suspended particulates, nitrogen oxides, carbon monoxide, hydrocarbons, and photochemical oxidants are the most common pollutants in the air. Lumping together all of these into the single category, air pollution, provides little information as to which specific pollutants should be abated, since the effects include phenomena of such disparate weight as discoloration of fabrics, deterioration of health, and fewer clear, sunny days. Air pollution is used as a summary term for these compound phenomena.

Although many of the effects of air pollution are evident, they are often difficult to measure. We do not know precisely what air pollution costs society in terms of human suffering and deprivation, not to mention financial injury. Many investigators have attempted to quantify and evaluate these effects. Lave and Seskin have elected to explore one aspect in detail, conjecturing that, if air pollution exerts an adverse effect on health, this alone would be sufficient to justify its abatement.

■ Let us begin with some useful oversimplifications. There are two types of air pollutants — those that come mostly from stationary sources (particulates, sulfur dioxide, and nitrogen oxides), and those that come mostly from mobile sources (carbon monoxide, lead, hydrocarbons, and nitrogen oxides). There are two measures

of ill health — sickness and death (morbidity and mortality). And there are two ways by which the health problems are presumed to arise from air pollution — chronic exposure and episodic exposure.

In living memory, several large-scale, disastrous episodes have provided the kind of public evidence needed to focus official attention on the relationship between daily mortality and daily air pollution.

The highly industrialized Meuse valley of Belgium experienced climatic conditions permitting the buildup of abnormally high levels of air pollutants (particularly sulfur dioxide) during December 1930. Over a five-day period, approximately 6,000 people became ill and perhaps 60 died (most of whom were elderly persons or those with previous heart and lung conditions). This was more than ten times the number of deaths that would normally be expected.

In October 1948, a similar event took place in Donora, Pennsylvania. Within three days, almost 6,000 people (over 40 percent of the population) became ill, and about twenty deaths were reported. This again was approximately ten times the expected number of deaths, and again the aged were most susceptible (the average age of the dead was 65). A follow-up study found that persons who became ill during the smog episode demonstrated subsequently higher mortality and morbidity than other persons living in the community. This was particularly true for persons with diseases of the cardiovascular or respiratory systems.

In December 1952, London was enveloped by a dense fog and in a two-week period 4,000 deaths were attributed to the abnormally high concentrations of sulfur dioxide and smoke. Unlike the previous episodes, all age groups were affected.

Lesser episodes occurred in London during January 1956 and December 1962. Nearly 1,000 deaths were attributed to the first incident. The greatest percentage increase in deaths was among newborn children. In absolute numbers, however, the greatest increase was among elderly persons. Bronchitis mortality exhibited the highest increase among specific causes of death.

Dramatic increases in air pollution have been shown beyond question to cause discomfort, illness, and death. Thus, the first hypothesized relationship between air pollution and health is an acute response, in which high concentrations of air pollutants have an immediate effect on health. Since there are a host of pollutants which might be responsible, some researchers have examined air pollution episodes to determine which pollutants were present, and numerous laboratory experiments have been run to explore the effects of individual pollutants.

■ The second hypothesized relationship is a more subtle one. There is a hidden dimension to the problem. The effect of air pollution on health may be related to exposure time. A long, or chronic,

exposure to low concentrations might be just as harmful to health as a short, or episodic, exposure to high concentrations. This long-term exposure may well exacerbate existing disease or increase susceptibility to disease. Evidence for this hypothesis is the finding that such substances as benzopyrene can produce cancer in laboratory animals, and the fact that acute irritation (demonstrated in laboratory experiments) can aggravate the symptoms of a chronic respiratory disease, and possibly make it progressive. However, concentrations of the magnitude required to demonstrate these effects in laboratories are seldom, if ever, experienced in urban air.

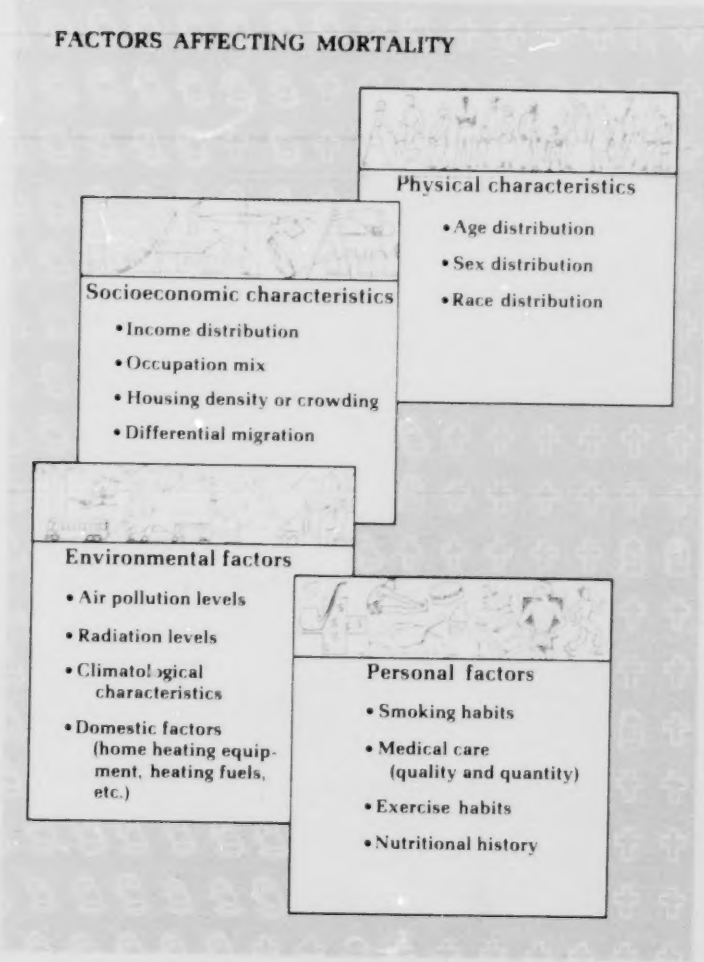
While there is no doubt that air pollution did cause illness and death in the episodes of Donora and London, there has been considerable uncertainty as to whether the levels of air pollution now prevailing in our major cities are sufficient to affect health. Although people living in cities are known to be generally less healthy (with lower life expectancies) than people living in rural areas, the question remains whether any part of this "urban factor" is caused by air pollution. Detailed and statistically sophisticated analyses are needed to explore the relationship between the level of air pollution and number of deaths. This research must not only establish whether there is an effect, but must also provide estimates of the quantitative impact of air pollution on the health of city populations.

We need to know, specifically, whether the effect of a given dosage changes with the time of exposure. For example, is an exposure of 10 parts per million (ppm) of sulfur dioxide for 10 hours better or worse than an exposure of 1 ppm for 100 hours or 0.1 ppm for 1,000 hours? If the physical responses to these exposures are quite different, laboratory experiments are not likely to provide satisfactory information for public policy toward air pollution. The body's repair mechanism has led to the prevalent view that there is a "threshold" above which the repair mechanism can no longer keep up with the damage; below the threshold level, no damage will result. If there exists a threshold level of air pollution that can be easily maintained by society, it makes sense for Congress to pass laws requiring that air pollution be abated to the point where no health damage is present. Such an attempt was indeed made in the 1970 amendments to the Clean Air Act. But if no such threshold exists, or if it is at so low a level that it cannot be maintained with current technology, the standards embodied in the 1970 amendments make little sense.

Though not yet agreed on such a threshold, scientists have been accumulating formal evidence for more than forty years that links ill health to air pollution. The scientific community has been slow to accept this evidence because of the methods used in gathering it and because of the lack of controls. Some early studies contrasted the mortality rates in polluted and unpolluted areas and found higher death rates in the polluted regions. The

problem with such analyses is that areas with high levels of air pollution are industrialized cities, whereas the areas with low levels of air pollution are rural farming communities. Put this way, the findings are not at all surprising: we know that people living in large cities have lower life expectancies for a host of reasons.

■ The principal conclusion that one might draw from a literature review is that many scientists have demonstrated an association or link between air pollution and increased mortality rates. What can one conclude from such a link? There are four logical possi-



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bilities: (1) the association is a sampling phenomenon and occurs at random; (2) air pollution causes an increase in the mortality rate; (3) increases in the mortality rate cause air pollution; or (4) there is a third factor that causes both air pollution and increased mortality, which gives rise to a spurious correlation between them. For example, if automobiles were the only source of air pollution, and if many deaths resulted from automobile accidents, there would be a significant correlation between air pollution and the mortality rate across cities. To avoid this spurious association, the number of automobiles, as well as such related factors as the number of miles driven and weather conditions, would have to be controlled in the analysis.

What can we say about these four possibilities? We can rule out the first, since there has been an enormous volume of evidence collected indicating a close association between air pollution and increased mortality. We conjecture that the second possibility is correct, but we must rule out the third and fourth in order to prove it. The third possibility seems macabre: perhaps in the 13th century the increased mortality during the Black Plague epidemics led to air pollution, but this hardly seems relevant today. Therefore, proving that air pollution is the cause of increased mortality depends upon being able to rule out the fourth possibility, i.e., that the association is spurious.

Generally, mortality rate is measured for a geographically defined group, such as the inhabitants of a city. A large number of factors are known to affect the mortality rate. Some of these may be grouped arbitrarily into: (a) physical characteristics of the population, (b) socioeconomic characteristics, (c) environmental factors, and (d) personal factors. The most important factors are the last, yet they are the most difficult for researchers to take into account.

In order to estimate the effect of any one of these factors on the mortality rate, the others must be held constant experimentally or controlled statistically. This is necessary because the estimated difference in mortality between two areas may reflect differences in a variety of factors affecting the death rate; one cannot ascribe the entire difference to one, such as air pollution.

An ideal investigation of the association between air pollution and health would control for all relevant factors. Unfortunately, many of them are difficult to measure conceptually (genetic effects, for example), while data on others either have not been collected (smoking habits) or are poorly measured in existing statistics (medical care). The difficulty comes in finding ways to control for each of the variables experimentally or statistically, explicitly or implicitly.

■ In practice, the laboratory has not proved to be a very useful setting for investigating the association between air pollution and ill health. There need be little relationship between the short-term

reaction mechanisms which can be explored in the laboratory using human subjects, and the mechanisms by which exposure to low levels of pollution over a period of many years exacerbates chronic disease. Even experiments involving the fumigation of animals over a prolonged period may have little relevance in studying the effects on humans, because of the differences in physiology and life span.

Because of these difficulties, the normally accepted method of using laboratory experimentation to prove causality may not be suitable. Indeed, the notion of causality may not be a useful concept in investigating chronic disease. Progressive lung damage could be caused by bacteria (or a virus), by occupational exposure to harmful materials, by smoking, by air pollution, or even by genetic factors. What is the cause of severe dyspnea in a 60-year-old asbestos worker who smokes, lives in a large city, comes from an impoverished family, and has never received proper nutrition?

A more useful approach for chronic disease involves determining which factors aggravate symptoms or make the disease progressive. In the given example, all of the factors named probably contributed to the dyspnea, and the absence of any one of them probably would have resulted in less severe symptoms. But the worker would not find such a conclusion helpful, nor would a public health official. They would find it more useful to know, for example, that breathing asbestos particles is ten times more detrimental than exposure to urban air pollution at the level experienced in the particular city.

Similarly, it is more useful to determine the extent to which sulfur dioxide increases the severity and frequency of emphysema than to investigate whether high concentrations of sulfur dioxide induce the disease in white mice under controlled conditions. Lave and Seskin's concern is primarily with estimating the effect of mitigating one of the insults, rather than with whether this insult is capable of causing the disease in isolation. For this reason, an epidemiological study that examines human beings in their natural setting is more relevant than a laboratory experiment. But to investigate the contribution of one insult, one must control for all the other variables believed to influence health. And research is further complicated by the likelihood that pollutants interact to produce more damage than each would individually. The effects of uncontrolled or unobserved variables will sometimes result in lending a spurious significance to the air pollution–health relationship; in other cases, in obscuring the association.

■ For a chronic disease, such as bronchitis, there is a long series of possible causes and aggravating factors. It is difficult, if not impossible, to control for each of them, e.g., genetic susceptibility. One is faced with a choice between two types of experiments.

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The first type of experiment represents classical epidemiology; it compares two groups which differ only in their exposure to air pollution. For example, one might look at the incidence of bronchitis among sets of identical twins, one of each set living in an area of low air pollution and the other living in an area of high air pollution. Studies of this sort may be quite suggestive, but they are not very helpful in estimating the contribution of air pollution to the incidence of bronchitis in the general population. These experiments also suffer from small sample sizes and limited ability to control for other factors hypothesized to affect the incidence of ill health; for example, a difference in exercise habits between urban and rural environments.

The second type of study examines the incidence of bronchitis among large, geographically defined groups, and searches for correlations among a variety of possible causes. Sample size is particularly important when a subtle irritant is involved and a number of other variables are uncontrolled. For example, in comparisons of the populations of areas exposed to different levels of air pollution, the inherent health-related factors will tend to balance out. When this is the case, a comparison between two substantial populations can be expected to show different mortality, morbidity, or physical-test results, if air pollution is the prime variable.

■ Of course, data on the characteristics of various city populations may not reveal some crucial traits needed for valid comparisons. People with severe respiratory difficulties may migrate from polluted to unpolluted cities. Suppose, for example, that everyone in New York City who has severe asthma or another chronic respiratory disease moves to an unpolluted city in the Southwest, such as Phoenix. This would mean that, even if the relatively clean air in Phoenix were to prolong the migrants' lives, the net effect of the migration of unhealthy people might be to raise the mortality rate in Phoenix while lowering the mortality rate in New York City. If there is a net migration of diseased people toward unpolluted areas, the result will bias the estimated coefficients of air pollution toward zero, and cause us to underestimate the association between air pollution and mortality. Carried to the extreme, so many sick people could migrate to Phoenix that the resulting death rates would be higher in Phoenix than in New York, and the estimated relationship between mortality and air pollution would show that air pollution is associated with lower mortality! The effects of migration have in fact been explored by Lave and Seskin in an analysis of the change in population in standard metropolitan areas (SMSAs) between 1950 and 1960. Migration appeared to have little bearing on the estimated effects of air pollution.

A similar distortion might arguably occur when people take less dramatic steps to reduce their exposure to air pollution. If persons

with respiratory diseases move within a city to a less polluted area, or if they install devices in their present homes to filter out pollution, the mortality rate is likely to fall. Behavior of this sort will affect the estimated association with air pollution. Insofar as such actions take place with greater frequency in more polluted cities, the mortality rate in these cities will be lower than "expected."

Another serious issue involves the error associated with air pollution measurements. In general, a single sampling station in a region generates readings that are reported biweekly. Since pollution concentration varies greatly with terrain, it is an heroic assumption to regard these figures as representative of an entire SMSA in making comparisons between metropolitan areas. Furthermore, measuring instruments change over time and differ from city to city, with some instruments having little reliability. At best, these air pollution reports are a remote approximation of the true current and cumulative exposure to air pollution experienced by the inhabitants.

■ Notwithstanding conceptual and technical problems of this magnitude, sound research has been carried out in the United States and elsewhere, and a massive literature is devoted to exploring the effects of air pollution on health. The vast bulk of this literature reports a significant association between air pollution and health. The recently completed research by Lave and Seskin gives much added weight and authority to that general conclusion.

Two statistical approaches were adopted, one involving broad-scale use of data on a great many cities, the other focusing narrowly on a handful of cities. In reviewing the broad-scale work, it should be conceded that the data available on particular cities could be seriously at fault. Yet, overall, it is believed that these deficiencies balance out and permit valid generalizations to be drawn for American cities taken as a whole.

For the year 1960 the mortality rates of 117 SMSAs were compiled so that the effect of air pollution could be estimated; socioeconomic variables were used to control for population density, racial composition, age distribution, and income. The two pollutants under consideration were suspended particulates and sulfates. The conclusion reached was that air pollution was an important factor in explaining variation in the total death rate across areas of the United States. To corroborate these findings, a partial replication was performed, using 1961 mortality and suspended particulate data, which gave largely similar results.

The analysis was then extended by disaggregating the total death rate into infant mortality, age, sex, race-specific mortality, and disease-specific mortality. A number of important problems that tended to obfuscate the association between air pollution and these disaggregated mortality rates had to be dealt with. These

included possible underreporting of the fetal mortality rate, inaccuracies in the diagnosis for the cause of death in disease-specific rates, and sampling variability when the disease was relatively rare (and the mortality rate was small) or when the population at risk was not very large.

Among the infant rates, particulate pollution was most closely associated with the deaths of infants under one year and under 28 days old, while sulfate pollution was most closely associated with the fetal death rate. In all, twenty-nine age, sex, race-specific mortality rates averaged over the years 1959 to 1961 were investigated. In general (except for the 15- to 44-year-old age groups), air pollution was an important factor in explaining the variation in these mortality rates across SMSAs.

Fourteen disease-specific mortality rates, based on both 1960 and 1961 data, were examined. For total cancers and four subclassifications of cancers, there was a close association with air pollution (particularly sulfates) in 1960, although the 1961 replication failed to indicate the same level of significance. Deaths from cardiovascular disease and its subcategories also showed a close association with sulfate pollution in 1960; in this case, the 1961 results further strengthened the relationship. For five diseases of the respiratory system, the results were generally insignificant. Only the tuberculosis mortality rate exhibited a close association with air pollution in both 1960 and 1961. Surprisingly, the mortality rates for asthma, influenza, pneumonia, and bronchitis did not display a relationship that was significant in both years.

For a subsample of fifteen metropolitan areas, data on three additional pollutants (sulfur dioxide, nitrates, and nitrogen dioxide) were investigated in an attempt to isolate their effects. In addition, major interactions among the pollutants were analyzed. Sulfates proved to be the deadliest pollutant in terms of general mortality. However, for the infant mortality rate, all five pollutants were statistically significant, and nitrogen dioxide was the most important in terms of estimated effect.

- In work focusing more narrowly on a small group of major cities, greater specificity was gained but generalizing power was much reduced. As with all previous work on this problem, RFF's study was limited by the availability of pollution data and, to a lesser extent, of mortality data. Daily observations on pollution levels (24-hour averages) were obtained from the Continuous Air Monitoring Program (CAMP). The data were most usable and complete for five cities — Chicago, Denver, Philadelphia, St. Louis, and Washington, D.C. — and for five pollutants — carbon monoxide, nitric oxide, nitrogen dioxide, sulfur dioxide, and hydrocarbons.

  In conjunction with the daily pollution readings, daily death counts from 1962 to 1966 were obtained for the five cities from a special study by the Environmental Protection Agency.

Finally, climatological data were secured on daily weather factors for the cities from the Department of Commerce. Air pollution, mortality, and climate information constituted the data base.

Results were similar for four of the five cities. There was no evidence of an effect of daily air pollution on daily mortality. The notable exception was Chicago, where, after controlling for climate and weekly effects, a close association was found between daily deaths and two pollutants — nitric oxide (primarily from automobiles) and sulfur dioxide (primarily from stationary sources). The effects of these pollutants on Chicago's population differed in their severity and timing. Sulfur dioxide was the most deadly, showing a large immediate effect on mortality, which gradually diminished over time. For nitric oxide the effect was delayed by several days, reached a peak, and then diminished. Further analysis ruled out the likelihood that deaths associated with air pollution were merely hastened by a few days — that is, that very vulnerable or mortally ill individuals who would have died a bit later were simply prodded along by the pollutants.

Some climate variables were significant in each city. Average wind speed was significant only for St. Louis, where increased wind velocity seemed to reduce daily mortality. This was plausible, since wind cleanses the air. Rainfall did not appear to have this effect. However, a lower mean temperature (coupled with air pollution) produced a rise in the death rate in Denver and St. Louis, whereas a higher mean temperature produced more deaths in Chicago. It is difficult to explain the different patterns in the three cities. For Chicago, however, it is possible to say that a 50 percent reduction in air pollution (as measured by sulfur dioxide) could be associated with a 5.4 percent reduction in that city's daily death rate.

A natural question arises as to why the data from Chicago alone confirmed a connection between daily mortality and daily pollution levels. One possibility concerns the relatively high levels of pollution that were prevalent in Chicago. For each pollutant under consideration, the mean level in Chicago exceeded the mean value for any other city. This was especially noteworthy for sulfur dioxide, for which Chicago's mean levels were almost ten times the levels of Denver and almost four times the levels of St. Louis. Even the low pollution months in Chicago had pollution levels far greater than those of the other four cities in this study. Thus, it may be that, at levels of pollution substantially below those found in Chicago, acute effects are not important. A closely related issue involves the relative size of the cities. Because of its larger population, the mean number of deaths per day in Chicago was more than four times as large as in any other city in the sample. Since deaths occur in discrete units (at least one at a time), effects of pollution in a smaller city may be lost when scattered over a five-day period.

Other studies, it should be added, have found similar close associations between daily mortality and air pollution in New York City and Los Angeles, both of which answer the requirements of size and high levels of air pollution.

- Before Lave and Seskin undertook the foregoing analysis, they examined a large number of studies documenting an association between air pollution and ill health. The conclusion from both their work and the work of others is that a significant association exists between various pollutants and death rates in large cities across the United States. Moreover, it appears that daily changes in the cities' air pollution levels have more effect on mortality than do annual changes. Where possible, every reasonable suggestion was tried to determine if the estimated relation between air pollution and mortality was spurious. In general, the conclusion has passed these tests and appears to be a consistent one. While this evidence cannot be said to prove causation, since there are still a number of factors affecting health which were uncontrolled in the analysis, it is substantial and, it is believed, sufficient to convince an unbiased observer of the relationship.

  The implication of the 1960 study for 117 SMSAs is that a 10 percent reduction in air pollution (as measured by particulates and sulfates) was associated with a 0.90 percent decrease in the total mortality rate. Analysis of 1960 data also suggests that a 50 percent reduction in air pollution (as measured by particulates and sulfates) would be associated with a 4.5 percent decrease in the total mortality rate. When a similar calculation was made from the corresponding 1969 data, it was found that a 50 percent reduction in air pollution (as measured by particulates and sulfur dioxide) would be associated with a 7.0 percent decrease in the total death rate.

- This work points to the need for a great deal of additional research to answer specific questions. An investigation of morbidity rates would probably be more useful than further studies of mortality rates. It is essential that the more difficult task of constructing reliable morbidity indices be accomplished, and that analyses similar to the one sponsored by RFF be carried out. Another crucial issue involves the question of which pollutants are harmful to health. For example, what is the toxicity of photochemical smog compared with that of sulfur dioxide?

  Some limited evidence has been produced that suggests that suspended particulates and sulfur oxides are important pollutants. For infants, suggestive although quite limited results lead to the conclusion that nitrogen oxides as well as particulates are quite toxic. Much more work must be done on toxicity, and it is likely that such investigations will require morbidity rather than mortality data.

Finally, the problem of estimating the effect of air pollution on human health requires better physiological evidence and identification of other environmental insults, such as radiation. A program should be undertaken immediately to estimate the doses of environmental factors experienced by a sample of the population, and to correlate these estimates with measures of the morbidity of the same sample. A careful experimental design together with appropriate statistical analysis of the data would add much to our understanding of the effects of man's environment on man.

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Low-Cost, Abundant Energy: Paradise Lost?

Most of the ingredients in the current energy discussion are familiar ones; it is the combination and configuration which provide the elements of severity and surprise. Not in recent times has the connection of events in the domestic economy been so dramatically underscored as by the emergence of energy shortages in one or another sector, with price rises as their harbinger. It is this interrelatedness of phenomena which forms the basis for a review of the energy scene today, written by Hans H. Landsberg, director of RFF's energy studies program. The following essay is adapted from the original, which represents the introduction to a report on social science research needs in the energy field prepared for the National Science Foundation during 1973.

The United States and much of the rest of the world have entered an era of profound alteration in traditional relationships, patterns, and long-accepted trends, in which what used to be taken for granted or was only rarely questioned has become an issue, a problem, a dilemma. Price relationships, usage rates, sources of supply, and, in its broadest conceivable meaning, national security and integrity, all have become areas affected with uncertainty and conflict — indeed such a degree of uncertainty that writing about energy developments carries a high risk of being obsolete before the ink is dry.

What follows is not intended to be an up-to-date chronology or news report, nor a set of policy prescriptions timed to the latest events and trouble spots. Nothing that has to be set in print weeks before publication can meet such a task. Rather this is an attempt to explain elements of the crisis, to explore the underlying trends and events that reach back long before (and are more profound than) the Arab oil embargo, and to look ahead beyond the immediate future with its day-to-day tasks of engineering quickly workable schemes for equitably sharing insufficient supplies with least damage to the U.S. economy.

The problem of supply is not generally unique to the United States, however. Energy prices have always been higher in Europe,

as every tourist pulling up at a gas pump in France or Italy has long known. Energy import dependency has been a fact of life for Japan, on a scale not even dreamed of in this country and of a degree only moderately smaller in most of Europe. Uncertainty of energy supply, both in availability at any given time and in quality of service, prevails through much of the world; most of industrialized Europe, Japan, and in fact all but a handful of countries get along on one-half the per capita supply, or less, of what has seemed to be a necessity for Americans, though their growth rates in recent years have far exceeded that of the United States.

Perhaps we are witnessing the closing of yet another frontier—the end of a low-cost, reliable energy supply in the United States. In any case, the changes are painful enough to evoke the specter of a "crisis."

■ Energy problems did not hit the country full-blown in 1973. There were much earlier hints of impending trouble. Among them were the refusal of numerous natural gas utilities to connect new residential customers, and voltage reductions and load shedding instituted by a number of Eastern electric utilities during peak load periods in each of the past two summers (though none as drastic as the Northeast power failure of November 1965, which has remained an isolated instance rather than the first of a series as some had feared).

Oil customers were affected next. In the late fall of 1972, shortages of heating oil prompted schools and other public buildings to close, and Midwestern farmers and their spokesmen in and out of Congress began to worry over securing enough fuel to dry wet crops and power their implements. By the summer of 1973, distillate and fuel oil and gasoline, as well as crude, were in short supply. Sunday or early weekday closings of service stations or "sold out" signs on the pumps are not sights the American motorist accepts with equanimity. That indeed spells crisis.

There were other indications. Electric utilities counseling customers how to "save a watt" or oil companies suggesting that motorists drive more slowly to make each gallon go further herald grave difficulties, no matter how much one discounts the advertiser's inclination to ride the crest of whatever popular theme comes rolling in. Since then, of course, mandatory speed reductions have taken over.

Yet another symptom was the increasing pressure for relaxation of environmental standards and controls. Both the automobile industry and numerous municipalities pressed for deferment of automotive emission standards; utilities sought temporary waivers of stack emission controls, largely in order to enable generating facilities to burn fuel of higher sulfur content; and high government officials asked environmentalists to be "reasonable," lest a backlash develop. Again, government action eventually replaced

voluntarism and "ad-hocism": variances in and postponement of achieving prescribed standards were becoming official late in 1973.

At the end of the product line, the consumer's — and the nation's — energy bill has been rising. Long a bargain, electric utility rates, as well as petroleum product prices, have started a rapid upward climb, not only in the United States but worldwide. Whether such changes are to be considered indicators of crisis depends on the context and the observer's background; but on the whole one would judge that (1) these price changes are the economy's mechanism of adjustment to changing conditions, and, like an ill person's rising temperature, they reflect the struggle to cope with the disturbance; and (2) the American consumer, who has seen outlandish increases in the price of many foods in the last twelve months, is not likely to revolt over higher electric bills or pump prices, unless they are unprecedentedly drastic and sudden. Yet, to the observer of the energy scene these changes signal basic maladjustments in the balancing of supply and demand.

Unless it is a short-term fancy of the kind the American motorist has taken to in the past, the surging sales of compact cars may represent the consumer's first adjustment to fears of higher prices and uncertain availability of gasoline. In the booming auto market of 1973, which betrayed no sign that buyers were in a mood to abandon their love affair with the owner-driven vehicle generally, small car sales during the first half of the calendar year reportedly constituted 40 percent of sales, up from 35 percent during the same period one year ago. Compacts, it is reported, sell at "sticker" prices; standard models at hefty discounts, if at all.

The rising tide of public activity offers further evidence that something is amiss. For both the executive and the legislative branches of government, energy policy has become a major concern. In less than three months the President has sent two energy messages to the Congress, twice addressed the nation on the subject, and in November sent Congress a legislative package authorizing him to take a number of significant corrective measures. Organizational regrouping has been frequent but less than radical, so far, in the search for an administrative machinery that might make a reality out of the old dream of coordination. Long-cherished policies like import quotas, eroded in the last stages of their existence, have been abandoned with little opposition. The flow of government energy research funds has steadily mounted. This year it stands just short of $1 billion, mostly for nuclear reactor development, and is projected to rise to an average $2 billion a year during the next five years, with somewhat more emphasis on nonnuclear energy sources. The federal government is also trying to set a good example in efficient energy use, in design of buildings to be erected, in the operation of its structures, in the choice and management of its vehicle fleets, and in other ways.

The Congress, for its part, has been immersed in a spate of measures to cope with energy problems. Prominent among them are efforts to: channel more public funds into energy research and development (S.1283); investigate competitiveness (S.2082 and associated hearings); promote the Alaska pipeline; establish a Department of Natural Resources and/or Energy, or some other central agency dealing with energy issues (S.70 and H.R.9090); and require environmental clearance and licensing for superports (S.1751). In addition, legislation has been introduced providing for: new procedures concerning power plant siting (e.g., S.935); land use planning that would affect just about every phase of energy production, transportation, conversion, and use (e.g., S.268, S.1081); deregulation of natural gas (S.371); and a national power grid (S.1025).

Finally, beyond the borders of this country, ever more frequent confrontation between the major exporters, banded together in the Organization of Petroleum Exporting Countries (OPEC), and their customers, and the seemingly unending string of short-term revisions in long-term basic compacts have reached their climax in denial of access to supplies and drastic, unilateral price boosts, with economic and political ramifications that could easily swamp the energy problem.

■ As in every crisis-like situation, an animated search for the villain is under way, and wisdom by hindsight abounds. In a country as rich as the United States, few are willing to believe that the consumer suddenly faces shortages simply because demand has run up against a real, albeit temporary, problem of supply. It must be someone's fault, and it may well be so though the usefulness of verification must be judged by its contribution to improved future performance. Three convenient targets present themselves: the energy industry, the federal government, and the environmentalist. As seen by their adversaries, the first conspires, the second bungles, and the third obstructs. The first is a knave, the second a fool, and the third a dreamer. *Industry* is accused of withholding supplies — and information on their magnitude, alleged to be much greater than reported; thus it creates shortages, higher prices, and, as a bonus, is able to cut supplies to — and the throats of — the minor performers (independent refiners and gas service stations). *Government* (in which, on the federal level alone, twenty agencies administer energy programs or implement or develop policies, supplemented by a number of special bodies in the Executive Office of the President) is charged with holding down prices, reducing incentives, cutting subsidies, and enmeshing industry in a thicket of agencies, standards, and regulations, causing profits to decline, capital to become scarce, and initiative to evaporate. *Environmentalists* are held guilty of halting the wheels of progress, following elitist aspirations, and shunning the "facts of life."

Not that these accusations are all new. The degree of competi-

tiveness between components of the energy industry and within each branch has been a subject of much controversy for decades, especially in respect to the oil industry both nationally and worldwide. Recently the assertion of "effective competition" in the natural gas industry has come under fire, and the merging of oil, coal, and uranium interests in large, inclusive companies has put in question competitiveness within the energy industry as a whole. It is thus not surprising that the blame for rising prices and spot shortages should be laid at industry's door.

■ Though the preceding survey of the energy scene lays no claim to exhaustiveness, it should have established as legitimate a search for the underlying trends, activities, or conflicts that have given rise to this variety of ever more drastic symptoms. The interconnections between the identifiable elements are numerous and often intricate. What is cause and what is effect is not always obvious, and it may not always be possible to make the judgment at all. We shall try here only to round up what would seem to an attentive observer to be obvious, major, active ingredients of the "energy problem," though not all firmly established as "facts" or "findings."

Perhaps most obvious to experienced and lay observers alike, demand has outrun supply at prices that have either been regulated or have risen only with some lag in time; hence, the "sold out" pumps, the nonconnected natural gas customers, the schools closed due to lack of heat, and the rising level of rates and prices. It is in the nature of the energy industry that, once its reserve margins of productive capacity have been exhausted, output can expand only slowly — that is, over a period of a few years rather than months. Anticipating the magnitude of future demand is thus of crucial importance and, given the time lag between planning and operation, such estimates must be pushed substantially into the distant future to serve a useful purpose.

Whether those involved in the anticipating — in or out of government — could have done better is a nice question (not limited, incidentally, to the energy field, as witness the rapidly changing food price predictions made recently by the highly skilled Economic Research Service of the U.S. Department of Agriculture, which escalated from a 3 percent increase predicted in November 1972 to one of 20 percent by August 1973). Let us take oil demand as an example. What has pushed it up so rapidly that, instead of the approximately 12 percent of consumption to be contributed by imports under 1958 limitations, imports by mid-1973 represented closer to 30 percent? One item has been the shift of electric utilities to oil, highly notable along the Atlantic Coast, and evident in the most spectacular manner in the Greater New York City area, where Con Edison and Long Island Light relied on oil for 22 percent of their fuel input in 1960 but for nearly 80 percent in 1971. For the Long Island company alone, oil in 1971 represented

over 90 percent of all fossil fuel used; it has not burned coal since 1969. Con Ed burned its last coal in February 1972 and is limited in its natural gas use to whatever is left over after its firm gas customers have been supplied. Controls imposed on emissions from fossil-fuel burning plants, the absence as yet of a commercially viable technology for removing sufficient sulfur compounds from stack gases, and tightness of natural gas supplies have caused utilities to shift to oil that meets the restrictions imposed. The effect on prices is not surprising. In the Middle Atlantic region, for example, cost to utilities of oil "as burned" rose 54 percent per barrel between 1969 and 1971, in constant dollars. In New England it rose 52 percent over the same period. Similarly, various industrial users have turned to oil and, within that category, to the less polluting, lighter distillates. This in turn has caused a tightening of oil available to heating customers. And all this before the Arab oil cutoff.

At the same time, automobiles, which account for nearly 40 percent of oil consumed in this country, have become less efficient converters of gasoline into vehicle-miles. There are several reasons for this. More power-consuming accessories on more cars (power steering, power brakes, air conditioners, and, more recently, emission control devices) are diverting part of the power produced from the drive shaft. At the same time, they have added to the car's weight, so that the same number of gallons will pull the car fewer miles. Data in this field need cautious interpretation. A recent account in the trade press (*Oil and Gas Journal*, April 16, 1973) reports that between 1970 and 1973 alone the weight of an otherwise comparable car has risen by about 300 pounds and that miles per gallon for that car have declined from 14 to 11.5. This, of course, exaggerates the impact; because of the large stock of older cars on the road, *average* mileage per gallon has declined much less. But the *direction* of change is beyond contention. Moreover, miles traveled per car per year have shown a moderate increase, after years of stability and despite the emergence on a large and rising scale of the two- and three-car family, a development that would have made one expect a drop rather than a rise in per-car mileage. All this is apart from the sheer number of automobiles, an upward trend that fails to reflect even the beginning of anything that could be called market saturation. Congestion in city streets and on highways adjacent to metropolitan areas could well have been another factor in lowering mileage (and increasing pollution) per gallon consumed.

All these factors have boosted demand for one or another of the oil refinery products. At a compound rate, gasoline demand rose by 2.6 percent per year from 1960 to 1965; it has risen at 4.5 percent since. Indeed, from 1967 to 1972 it rose by 27 percent, or 4.9 percent per year. Consumption of middle distillates increased even more rapidly, by 5.2 percent from 1967 to 1972; and demand for residual fuel oil, the one-time Cinderella of refinery

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products that had risen by barely 1 percent per year from 1960 to 1965, shot up by an annual rate of 7.2 percent over the latest five-year span. This is the story for 1972, in percentage increases over 1971: gasoline, 6.0 percent; distillate, 8.5 percent; residual fuel oil, 10.1 percent; total product demand, 7.3 percent.

Yet these growth rates are moderate compared with those that have prevailed in the rest of the world. Demand for gasoline in Western Europe has risen by an annual 10.8 percent during the decade ending in 1972; for middle distillates, by 12 percent; and for residual fuel oil, by 9.2 percent. Comparable figures for Japan are 8.8, 10.3, and 17.8 percent.

■ In the United States, recent increases in consumption have no match on the supply side, no matter what measure one selects. Leading oil states like Texas and Louisiana now are lifting oil at essentially 100 percent of rated capacity — that is, capacity calculated at a rate of extraction designed to result in maximum economic recovery, with none to spare. Through 1972 the trend of exploration activity and drilling was down, while refinery construction increased only slowly. Drilling activity, for example, measured in well completions, had by 1972 declined to the level of 1946, following a sharply rising trend that began in 1948 and persisted through 1956, when completions had almost doubled over the number recorded eight years earlier. As a result, reserves, as defined in the industry statistics, have declined absolutely, and even more drastically as a multiple of production. The 1973 turnaround in gas drilling activities is encouraging but too recent to evaluate as a guide to future events.

In its most generalized form, the strong demand situation is reflected in the relationship between energy consumption and gross national product. Widely commented on, insufficiently understood, and variously explained, growth of energy consumption, as measured in the heat content of primary fuels and the fuel equivalent of hydro and nuclear power, outpaced that of the economy between 1967 and 1970, leveled out in 1971, and fell behind economic growth in 1972. The significance of this most recent decline in the energy/GNP ratio, which in more normal times might have been seen as heralding a return to the long historical trend, is quite uncertain, as the rate of growth in energy consumption may come to be forcibly reduced rather than determined by market forces.

Promising new avenues of supply expansion have narrowed or closed altogether. Offshore drilling received a heavy setback from the Santa Barbara Channel spill. Existing wells had to be throttled and new ones could not be drilled. Moreover, the event cast a shadow over offshore drilling as a whole, particularly threatening to future supply in view of the richness of the offshore fields and their rising relative role in recent years (from 4.5 percent of total

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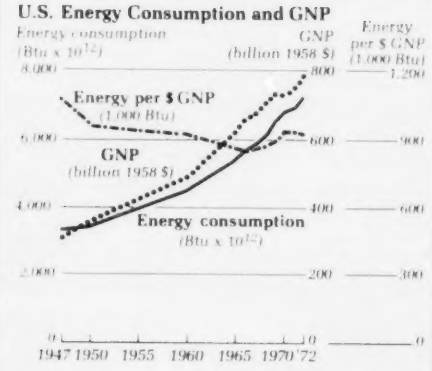
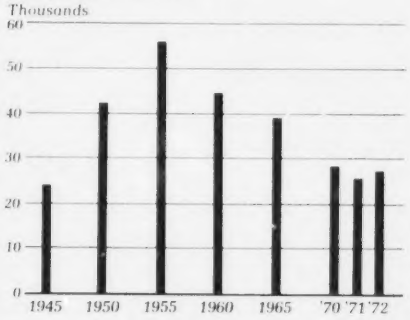
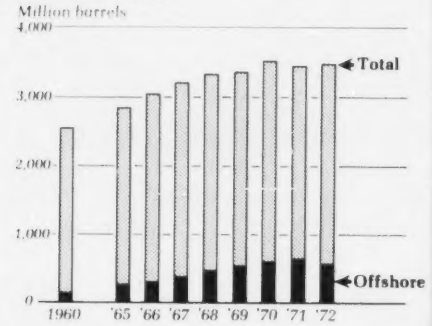
U.S. Energy Consumption and GNP



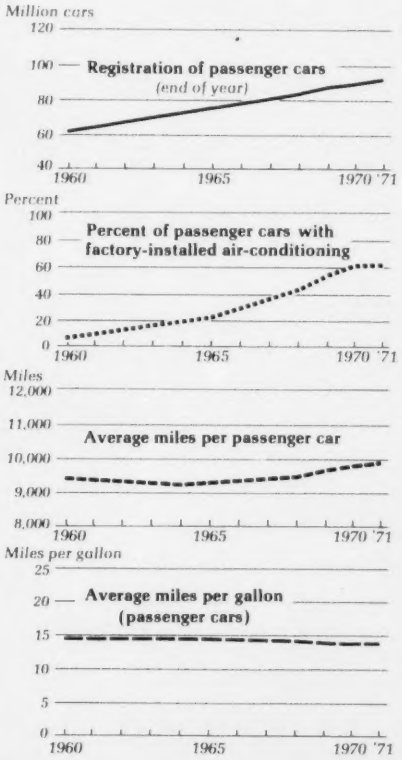
Number of Oil and Gas Wells Completed in the U.S.



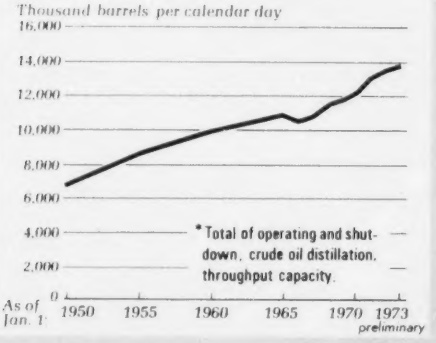
U.S. Crude Oil and Condensate Production, Total and Offshore



Selected Data on Automobiles, U.S.



U.S. Crude Oil Capacity at Refineries*



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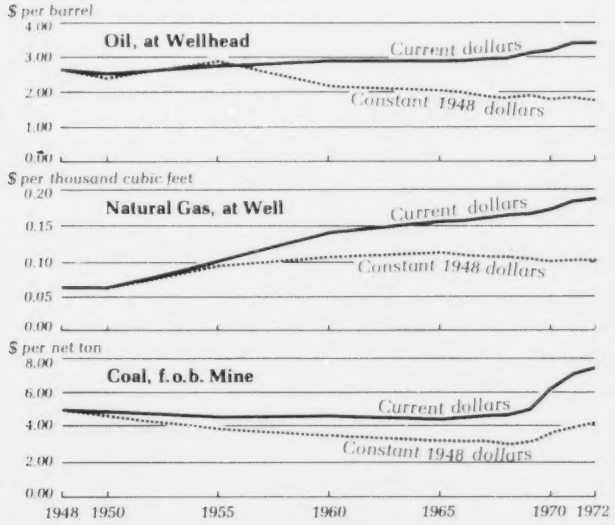
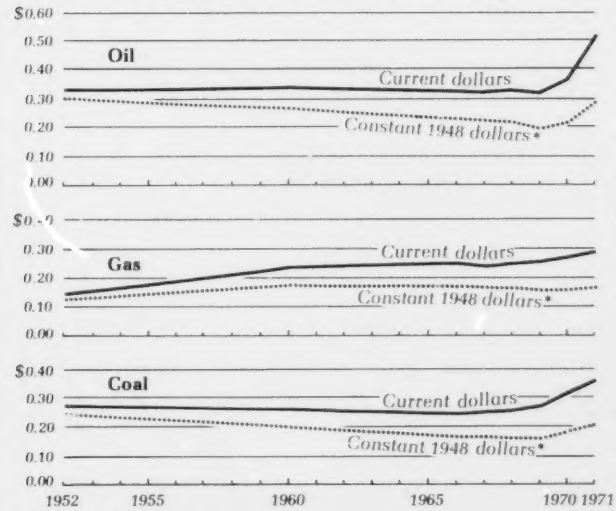
Average Values of Oil, Gas, and Coal, in Current and Constant Dollars



Costs of Fuels ("as Burned") to Electric Utilities, in Current and Constant Dollars, United States Average



*Deflated by GNP deflator, 1948 = 100

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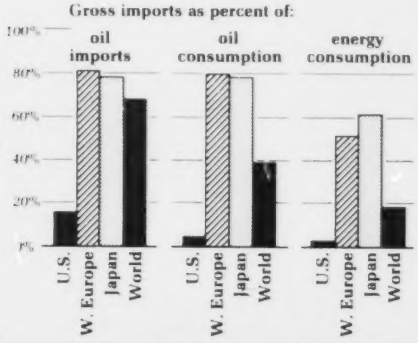
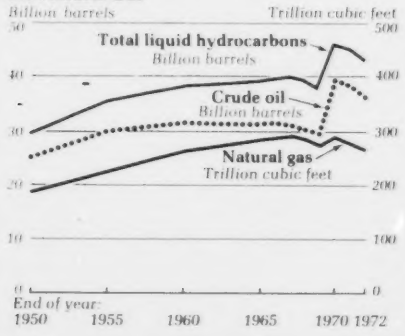
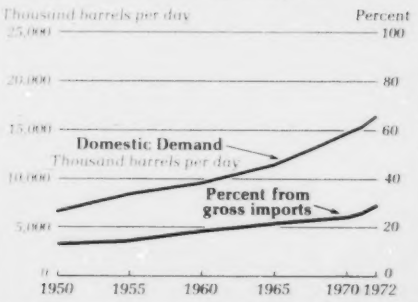
Significance of Oil Imports from the Middle East and North Africa, 1972



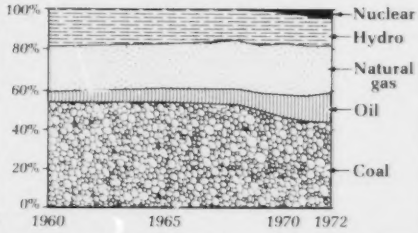
Proved U.S. Reserves of Total Liquid Hydrocarbons, Crude Oil, and Natural Gas



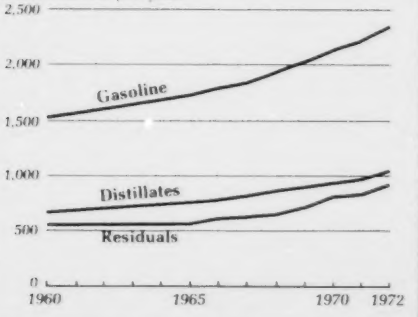
U.S. Petroleum Demand and Imports



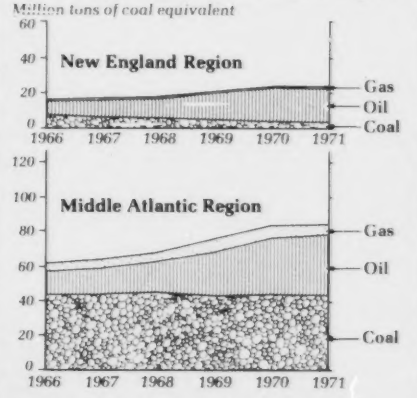
Percentage Shares of Sources in U.S. Electric Energy Generation



U.S. Domestic Demand for Selected Refined Petroleum Products



Fuel Consumption by Electric Utilities in New England and Middle Atlantic Regions



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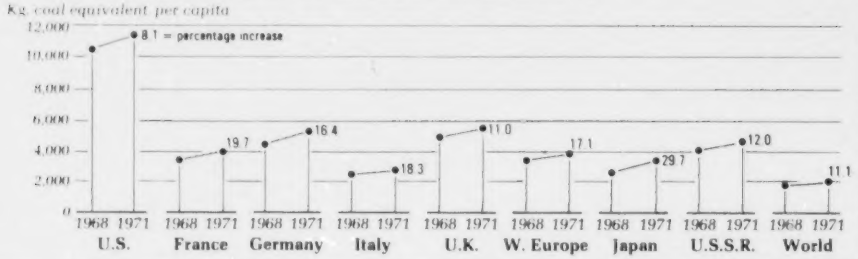
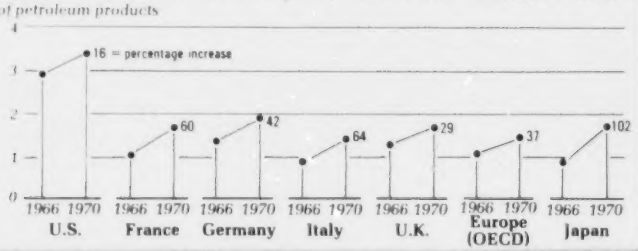
Per Capita Energy Consumption, Selected Countries, 1968 and 1971

k.g. coal equivalent per capita



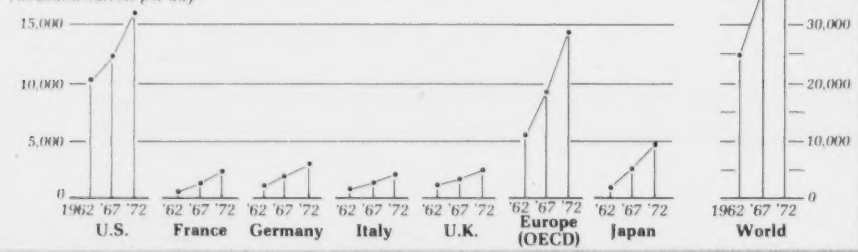
Per Capita Inland Petroleum Consumption, Selected Countries, 1966 and 1970

Tons of petroleum products

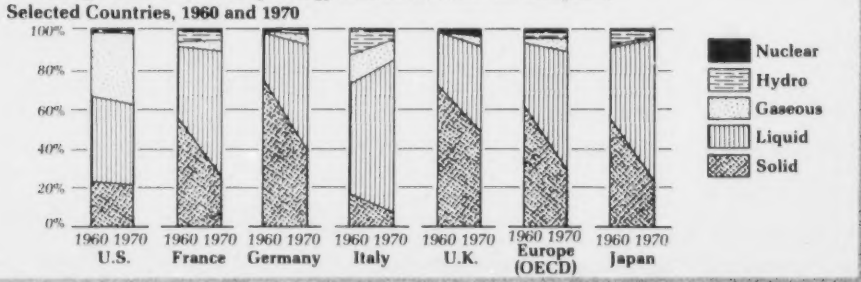


Petroleum Consumption, Selected Countries, 1962, 1967, and 1972

Thousand barrels per day



Percentage Shares of Primary Energy Sources in Total Consumption, Selected Countries, 1960 and 1970



crude and condensate production in 1960 to 16.4 percent in 1972). No less significant has been the delay of production of the Northern Alaska field. The merits of the two cases aside, had offshore drilling and producing continued as foreseen and had North Slope oil come into operation, these two sources could have contributed about two million barrels per day by now — substantially more than 10 percent of demand, or more than a third of current U.S. oil imports and thus roughly the equivalent of direct and indirect imports from Middle Eastern sources. Moreover, production of North Slope natural gas on the heels of that of oil would have eased the demand that oil make up for the natural gas shortage.

Associated with this slowdown in domestic production is a record of declining *real* energy prices, masked by price increases measured in current dollars. Thus a barrel of crude oil was worth $2.60 in 1948 and $3.39 in 1972, with only a slow upward trend until the very recent rise. In constant (1948) dollars, however, the 1972 price reached not $3.39 but $1.85, for a decline of about 50 percent during the quarter century. To put it differently, any 1972 price below $4.75 per barrel represented a decline in the real price of oil since 1948. At $3.39, oil in 1972 lagged about 30 percent behind the rise in the general price level.

The price decline was even more pronounced in coal, which, beginning in the mid-sixties, had come under the cloud of tightening environmental regulation of both mining and combustion practices. At the same time, coal's price in constant dollars had declined by some 40 percent between the early postwar period and 1970, then increasing very sharply as a number of phenomena created a sudden shortage of coal, specifically of low-sulfur coal — though here again the long slide in coal's real price must be taken into account when contemplating its subsequent rise. Recent price increases are most dramatically revealed in company annual re-

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The illustrations on the preceding pages are based in part on figures from the following sources: American Gas Association, *Gas Facts: 1971 Data* (1972); American Gas Association, American Petroleum Institute, and Canadian Petroleum Association, *Reserves of Crude Oil, Natural Gas Liquids, and Natural Gas in the United States and Canada and United States Productive Capacity as of December 31, 1972* (1973); American Petroleum Institute, *Petroleum Facts and Figures (1971 Edition)*; American Petroleum Institute, *Quarterly Review of Drilling Statistics for the United States* (Feb. 1973); British Petroleum Co., Ltd., *Statistical Review of the World Oil Industry (1972 Edition)*; National Coal Association, *Steam Electric Plant Factors* (1960 and 1972); OECD, *Oil—The Present Situation and Future Prospects* (1973); United Nations, *Statistical Yearbook 1972* (1973); U.S. Bureau of Census, *Statistical Abstract of the United States: 1972* (1972); U.S. Bureau of Mines, *Mineral Industry Surveys*, "Petroleum Refineries Annual" (1972); U.S. Bureau of Mines, *Minerals Yearbook* (various years); U.S. Bureau of Public Roads, *Highway Statistics (1970 Edition)*; U.S. Department of Interior, *Outer Continental Shelf Statistics* (1973); and U.S. Department of Interior, *United States Energy through the Year 2000* (1972).

ports. For example, Pennsylvania Power and Light registered a rise of 9.9 cents per million Btu of fuel purchased between 1970 and 1972; Detroit Edison, of 11.1 cents over the same period. Other companies show similar trends. Only the price of natural gas had advanced in real terms, but that advance had been accomplished by the late fifties.

To a considerable extent, then, recent events in the price arena mark the end of energy as one of the great postwar bargains. Other factors have, however, aggravated the situation. One of these, already mentioned, has been the slow pace in refinery construction, most pronounced along the East Coast, where no new refinery has been built in the last fifteen years and capacity has in fact been declining since 1961. This trend is frequently blamed on environmentalist opposition, perhaps because such episodes as protracted and hitherto unsuccessful attempts to locate a refinery in the state of Maine give high visibility to the activists. However, not only does the condition precede public environmental concern, but other factors — mostly within control of the government — are probably involved. Import limitations and uncertainties as to their duration and character, possibly capital tightness following the reduction in the depletion allowance, the suspension of the investment tax credit, tax advantages for location offshore, the uncertainties concerning the type of gasoline to be marketed (role of lead), and the rising difficulties of obtaining sweet (low-sulfur) oil, which the bulk of U.S. refineries are built to process, have all at one time or another contributed to the failure of refining capacity to keep pace with rising demand. Actually, refining capacity has not stood still, even in the most recent past. It rose by about 4 percent annually, from 1967 to 1972, and by 1.2 percent from 1971 to 1972. In the face of rapid demand increase, however, this limited expansion was not nearly sufficient, and the late sixties saw a rising dependence on product imports. Even if fully implemented, and assuming access to additional crude, the wave of recently announced planned capacity growth cannot soon remedy this condition.

All the foregoing might not have conjured up the idea of a generalized "energy crisis," had it not coincided with substantial delays in the expansion of the electric power industry. Here, too, the reasons were manifold, and it would be wrong to hold environmentalists solely or even largely responsible. Rather, as many had anticipated, the nuclear power industry has been plagued with childhood diseases, including unsuspected technical problems, poor workmanship, congested order books, strikes, and other delays not peculiar to the power equipment industry but acutely felt in conjunction with other delaying events — slowness of the licensing process, multiplicity of agencies involved, and time-consuming tests in the courts. These, together with the concern of environmentalists about routine as well as accidental

emission of radioactive substances, safe management of disposed material, thermal pollution of lakes and rivers, and the like, have slowed down the planned expansion of the industry.

Nor were there ready alternatives. Supplies of natural gas, the "clean fuel" par excellence, were becoming increasingly tight. Its use as boiler fuel once again was frowned upon, just as it had been some twenty years ago. And indeed, as mentioned above, gas is the only fuel that has registered an increase in real price, primarily because it had been so drastically underpriced when first coming into use as a by-product of oil extraction. Even in 1972, its wellhead price of approximately 20 cents per million Btu compared with 30 cents for coal (at the minemouth) and 60 cents for wellhead oil.

Regulatory policies have played a part in perpetuating the price differential, keeping the price of gas below the level at which the market would be cleared without the "shortage" phenomenon that now prevails. Not that there is any agreement among students of the subject on how diminished regulatory control would affect development of new reserves, or production. Some expect it would result in greatly expanded exploration and development activity, greater production from existing reserves, and somewhat reduced demand. Others believe that, although production might rise as exploitation of high-cost reserves became profitable with higher prices, reserve development would be little affected, since, in their judgment, the current shortages are due not to lack of reserves but to deliberate suppression of productive capacity, extending even to the "cooking" of relevant statistics. Whatever the cause of deficient supply, there is no disagreement over its consequences: a substantial amount of unfilled demand at the prevailing, regulated price of natural gas.

As for coal-fired boilers, a reliable, commercial process for desulfurization has yet to be demonstrated, occasional reports to the contrary notwithstanding. Utilities have thus been reluctant to commit funds to coal-fired plants, an attitude strengthened by the judgment that problems attending nuclear generation will in time be solved and that the nuclear plant thus represents a wiser long-term investment. The lopsided allocation of research and development funds, with the overwhelming emphasis on nuclear energy, has not helped matters. Current efforts at correcting it would bear fruit only in the years to come.

Nonetheless, there are tenuous indications that, of the many problems besetting the energy industry, those that have slowed down the electric power industry are perhaps receding in severity. Reserve margins, a good indication of the industry's physical capacity, are lengthening ever so slightly. In the summer of 1973 they reached 20.4 percent for the industry as a whole — up from 19.6 percent a year ago; barring new delays or some basic blockage, they could be climbing toward 25 percent in the next two or three years, as government efforts to speed the licensing

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processes are successful and new plants come on stream. On the other hand, precisely because a great many of the large (800 to 1,200 Mwe) nuclear plants will be entering service, one should be prepared for unpleasant surprises as operating experience is gathered.

■ Against the factual background sketched above and reflected in phenomena increasingly visible to consumers, let us summarize a number of issues that these developments have placed on the agenda: import dependence, expansion of domestic capability, and environmental trade-offs.

However, one line of attack is perhaps best dealt with in advance because it parallels whatever else is done. That is the multitude of possible efforts to have energy, wherever and however produced or converted, utilized more efficiently. Some results might come quickly, such as a turn to car-pooling and maximum use of available mass transit facilities. Higher gasoline prices, rationing, or a combination of both can assure reduction in consumption. So will other governmental moves, authorized or initiated in mid-November. On the other hand, to expect that appeals to voluntary economizing will bring substantial results is perhaps to risk disappointment. Partly, one deals here with inducing change in deeply entrenched habits not likely to yield swiftly, and with changing the nature of producer and consumer durables where annual output represents only a small increment to a large stock whose built-in performance characteristics will tend to resist the achievement of energy-saving practices. Partly, the political process shrinks from imposing unpopular demands on the citizenry. Partly, a whole arsenal of institutions would have to be radically altered in order to work as energy-saving mechanisms. Moreover, the link of the individual's action to, or abstention from, the big picture may be too tenuous to rely on for motivation and achievement.

Nonetheless, there has developed a lively discussion around what is often referred to as "energy conservation." Price increases alone can be expected to slow down demand, though our scant knowledge of price elasticities of energy as a whole and of its components suggests more about the *direction* of change than about its likely *magnitude*. We know that consumers purchase energy in driblets. This diminishes the demand-reducing effect of price increases. More potent deterrents, such as progressive taxes on energy-consuming durables, especially automobiles, have come into view but not as yet into operation. Changes in transportation patterns (mass vs. individual media), buildings that minimize heating and cooling requirements, and other modifications of major living arrangements tend to have long incubation periods. Nonetheless, marginal adjustments are taking place even now. Reductions in airplane cruising speeds, the reported buyers' shift to compact cars, and producers' intentions to respond by shifts in their output

mix are examples. The effectiveness of admonitions to reduce driving speeds on highways, on the other hand, has quickly given way to mandatory reductions in official speed limits. Altogether, gradual, socially motivated changes in behavior, not to be confused with the fashionable and ill-defined label of "changing life styles," are not to be discounted. Setting the thermostat a couple of degrees higher in summer and lower in winter, or doing with less illumination in offices and at home could well be contagious responses to social pressure. Beyond that, changes in arrangements for shelter or transportation or for meshing the work-home-leisure pattern in a society built around abundance of space and energy should not be expected to come rapidly or massively, though there is room for argument and for contribution from the academic disciplines. Moreover, it is probably true that improved efficiency in use is the one area that can improve the demand/supply balance in the short run.

Until November 1973, nobody doubted a continuing shift in supplies from indigenous to foreign sources, involving principally oil and, to a lesser degree — largely because of technological newness — natural gas. Its magnitude and duration were less easily agreed on. Nor was it asserted that there were immutable factors at work and no possibility of reversals. On the contrary, the new devotion to energy research and development, symbolized by the government's willingness to fund it at the annual rate of $2 billion, was regarded as likely to provide the pivot on which the growing dependence could eventually turn around. The cutoff from Middle East oil has made import dependency a burning issue and shifted the focus of the debate.

Concern over import dependency is not new. In its most conventional form it rests on considerations of national security. It asks what degree of dependency, and therefore vulnerability, is tolerable, and what alternatives exist for ensuring adequate security in the face of growing dependency.

Such concern has gradually extended its scope. In the future, security is likely to be more broadly conceived — as reliance on a minimum flow of energy materials to feed the economy as a whole, not just the defense machinery or the economy in times of war. In that perception, two strands can be distinguished: (1) the impact on the nation's foreign trade and payments balance with implications for broad-gauged competitiveness in world trade, and (2) the effect on United States foreign policy in a world where competition for fuel easily becomes a major disruptive influence among friends (Canada, Western Hemisphere, NATO, Japan, etc.) and a potent determinant of the existence and strength of new alliances.

Relations with OPEC countries located in the Middle East and along the southern shore of the Mediterranean have, for many years, been heavily affected by energy questions, but that was principally through the medium of security for Western Europe

and the role of U.S. companies as operators in that part of the world. Now and in the future, the far more direct impact of oil (and gas) supply to the U.S. market and the impairment, if not the loss, of American ability to help Western Europe and Japan overcome sudden supply difficulties by reaching into current U.S. production will give new importance and urgency to the foreign policy aspect. At the same time, how the exporting nations will invest their growing oil revenues, assuming that large exports will take place even if not at rates desired by many potential customers, is an altogether new, and so far unanswered, question.

Of equal novelty is the idea of the USSR as a large-scale supplier of energy, in this instance natural gas, to the United States. Here security considerations of a different kind are bound to generate searching debate. Finally, rethinking the security concept will become necessary in the wake of recent evidence that Canada is reluctant to remain an unquestioned reserve pool for U.S. needs. "An important policy question," a recent Canadian government document states, "relates to whether energy resources which may be surplus to Canadian needs should be developed for export to what appears to be an insatiable U.S. and world market." The customary assumption that U.S. dependence on foreign supplies is acceptable as long as such supplies are located in adjacent areas, or at least within strategically easy reach, could come in for review, modification, and perhaps abandonment.

Viewed in isolation as a purely economic phenomenon, the trend toward obtaining a growing share of energy supplies from abroad should not give rise to great concern. It is a stage in the cycle of development and foreign trade, through which other commodities have passed at other times and in other places. However, not only does U.S. demand pressure hit the country at a time of precarious foreign trade and payments circumstances, it coincides with similar pressures in the rest of the industrialized world; both Western Europe and Japan depend on imported supplies to a far greater degree than does the United States. Indeed, Japan is 100 percent import-dependent on oil and derives nearly 80 percent of its coking coal from abroad as well. Moreover, the 1960s have witnessed a radical swing in both Western Europe and Japan to oil as the primary energy source. Thus, plans for "sharing" were looked at askance by Europe and Japan even before the Middle East war, while now there is less to share and less willingness to do so. As a result, the world's oil producers find themselves, for the time being, in an unprecedentedly strong bargaining position, which has enabled them to convert rising demand into rapid price and revenue increases. Even if trade relations should return to a state of normality, such revenue increases will have affected the economics of expanding production (why sell now if prices will continue to rise?) and reduced motivation in terms of collecting more revenue (what is to be done with the already snowballing billions of dollars that may by the end of the decade total $30

billion or more?). Thus, even steeply rising prices may not be accompanied by a satisfactory expansion of crude oil supply from some foreign sources. High prices and moderate exports, if the cartel holds, could be an attractive alternative. Nor are refined products available on short notice, even under normal conditions of supply; especially not gasoline, which represents only 12 percent or so of the European refinery mix versus nearly 50 percent in the United States.

■ A decision to combat growing import dependence has its correlate in policies designed to increase the contribution of domestic sources, with careful attention being given to the relative costs for the economy as a whole. After all, attainment of a greater degree of self-sufficiency could easily be self-defeating if it imposes burdens on the rest of the economy that would reduce its strength and competitiveness. Although the nation has lived with almost total import dependence as a "fact of life" for materials like nickel, manganese, chromium, and bauxite, and has carried on only modest research to probe potential domestic sources or new substitutes, one cannot realistically expect a similar attitude when the phenomenon shows up in basic energy materials.

In exploring avenues for expansion of domestic sources, it is well to distinguish between short- and long-run means, where the next decade, say the years through 1985, may be considered the short term. In the latter context, the resumption of oil and gas production from offshore sources, under appropriate environmental safeguards and guided by the lessons of past accidents and their consequences (still a controversial area), comes immediately to mind. So does the completion in one way or another of the effort that will bring Alaskan oil and gas to the West Coast and/or the Midwest.

Less controversial but often neglected in the ardent search for new zones of production are advances in the art of finding and recovering oil and gas. It has been almost ritualistic for students of the industry to assume a steady climb in the ability — and the practice based on it — to locate producing zones and, in the case of oil especially, to recover increasing portions of the material originally in place. Instead, we have witnessed a decline in exploration and drilling and little progress in bringing more oil to the surface. Much of the liveliness of research in the mid- and late fifties, when new recovery methods were engineered and tried, and hopes were high for bringing 50 percent and more of oil in place to the wellhead, seems to have gone. The anticipated fruits of satellite surveys to locate new zones also have been slow in maturing. Increased attention to exploration and recovery techniques as a short-term measure has consequently been suggested.

Since U.S. coal reserves are measured in hundreds of years, even at rising annual rates of consumption, achievement of a "clean-burning" coal would seem to be of utmost importance. As

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has already been stated, technology has lagged in developing a process that would make such coal less costly than desulfurized oil or natural gas. Success would quickly lead to an easing, if not a solution, of a major supply problem and is well within the focus of the short term as here defined, though not an instant remedy as is sometimes casually assumed.

Hand in hand with greater emphasis on technologies that promise short-term gains go incentives and policies designed to make the search for and use of such innovations attractive to producers. Whether there should be a more relaxed — and perhaps even positive — attitude toward price increases that reflect changing supply/demand relationships and must thus be distinguished from "inflationary" factors; whether, and what kinds of, special tax treatment, credit, allowances, etc., are indicated; whether there should be, as in the case of natural gas, less public regulation; whether and how federal funds are to be used to supplement private efforts — these are just a few of the questions that will be in the forefront of discussion. Research will bring others to light, and in their consideration controversy will abound. The oil industry, for example, has traditionally been eyed with suspicion by a broad segment of the public. Suggested incentives for better performance in order to achieve expanded domestic capacity are likely to be critically scrutinized; today more than ever, promoters of extractive activities must demonstrate that these are in the public interest. Nonetheless, energy conservation aside, enlarged domestic oil and gas producing capacity presents the major, if not the only, short-term antidote to increased import dependency. Policies designed to support it and research activities to guide policy therefore deserve great attention.

- Truly new energy sources or conversion methods to replace those approaches now narrowed or closed altogether by environmental problems are apparently not around the corner. There is little dissent from the judgment that coal conversion to either gaseous or liquid form, to supplement petroleum and natural gas supplies, will not make much of a contribution before the early or mid-eighties. Moreover, should drastically higher prices elicit an equally drastic supply response from oil and gas producers, the early need for producing liquefied or gasified coal would greatly diminish.

  The technique of extracting oil from bituminous sands is now well advanced, though the largest operation, begun in 1967 in Canada, is yet to break even financially. No sand zones comparable to those of Alberta have been identified for early development in the United States, nor are there moves to proceed in that direction. Thus, expansion will come in Canada, if at all, and its benefit for the U.S. energy economy will at best be indirect.

  Such indicators as rising crude oil prices, proposed lease sales of rich shale oil land by the Department of Interior for construc-

tion of prototype shale oil plants, and various economic studies suggest that the start of a shale oil industry could be in the offing. Similar indications in the past, however, have come to nothing. Moreover, there are still unresolved environmental issues concerning the development of oil shale. A cautiously optimistic view appears warranted at present. In the long run, lack of processing water may limit the size of a Rocky Mountains shale oil industry.

Any impact on the nation's total energy supply by most remaining technologies is probably even further in the future, not excepting advanced nuclear reactors — specifically, the breeder. Given the time it has taken nonbreeding reactors to come into their own, as well as the fact that a breeder prototype is only now beginning to be engineered and put in place, a significant contribution within the next fifteen to twenty years is excluded. Even "shelf-item" reactors now have a lead time of eight years or more. Recent orders placed by utilities generally specify operation no sooner than 1980. In a March 1973 tabulation of nuclear plants on order, in instances where the vendor of the nuclear steam system had been specified, twelve out of thirty-three units that had submitted their construction-permit application listed planned commencement of operation in 1980 or 1981. Of forty-seven orders for which construction-permit applications are only in the preparatory stage, thirty-seven listed the start of commercial operations in 1980 and beyond, some as far ahead as 1983. Finally, a group of fifteen orders for which no vendor had been chosen showed that all were scheduled to commence operation in the early 1980s. Against this background, to set the time of the first operating commercial breeder reactor even as soon as the middle 1980s is perhaps optimistic, especially since adverse environmental considerations and arguments have yet to reach their full flowering.

It follows that the timetable for the emergence of commercial power derived from fusion is likely to take us into the next century. Nor is success a foregone conclusion. This does not, of course, say anything about either the timing, magnitude, or provenance of research and development funds. Uncertainty of eventual success and a long lead time are merely to be considered in setting priorities, in conjunction with the likely impact of successful outcome and the capacity of the research community effectively to digest rising funds at each stage of work.

Both geothermal and solar energy are properly considered "new sources," since their present employment is spotty; it takes place under unusual circumstances, as far as geothermal is concerned, and on a more or less experimental basis in the case of solar energy. Though these two approaches, unlike fusion, are technically feasible today, they are likely to be important supplemental sources only in the more distant future. At the same time, greater attention to the untapped potential of the earth's inner heat has already given life to a wholly new concept of exploiting it: the

sinking of deep shafts, possibly blasting the holes with nuclear devices, and utilizing the heat of the rock masses to turn injected water into steam, to be raised and used in conventional generation. As a new technology, beginning to be investigated in the early 1970s, it is not likely to have an early pay off equaling that of shale, tar, or coal conversion but, if commercially viable, it could come into play during this century. In several respects it is more attractive than traditional geothermal energy.

For good reason, solar energy has drawn increasing attention. Above all, at least on a global basis, its use would essentially free us of the thermal discharge penalty. It would thus get around atmospheric and climate problems and obviate limitations of energy use as an ultimate "limit to growth." Technology, however, is far behind the expectations aroused by popular writing. Even the more feasible applications of solar energy for heating and cooling residential and other structures would require major changes in building design, practices, and associated institutions. If adopted, it would gain importance slowly with the accretion of new housing to the existing stock, and probably not without a determined governmental drive to assure acceptability and a mass market. This does not promise early relief for the prevailing and expected future tightness of heating sources. As for electric power from solar energy, the conversion efficiency of the various devices so far designed is still exceedingly low. Some of these devices require large land surfaces, others outer space bodies, and none so far seems to have reached a degree of economic feasibility akin to that of most other novel technologies.

■ To sum up then, expansion of domestic capability in the near future will depend principally on (1) establishing effective incentives for exploration and discovery of oil and gas resources as yet unidentified, and for more efficient recovery of those already known and developed; (2) bringing into operation, with acceptable environmental safeguards, Alaskan and offshore resources, and whatever other occurrences might be revealed; and (3) expanding the use of coal (as coal) so as to widen its application within acceptable limits of environmental impact.

Beyond these measures lie resort to oil shale and tar sands, the latter necessitating an understanding with Canada; to coal conversion; to the breeder reactor and eventually to geothermal, solar, and fusion energy. Not all of these are technically proven technologies, nor will demonstrated feasibility necessarily lead to utilization. Coal conversion and shale oil production will have their timetables strongly influenced by the response of oil and gas production to changes in incentives. Successful shale oil extraction might for a long time push coal conversion into the background, or vice versa. Thus, which items will be picked from the offered menu is as yet uncertain.

Because environmental concern and action have become so highly visible, it is easy to exaggerate their constraining impact in the current energy situation. For example, a nuclear power plant's schedule delayed by careless manufacturing methods is much less dramatic — or dramatized — than court action by an advocate group. Yet available data suggest that fewer delays are caused by advocate groups than by technological and engineering problems — not surprising, after all, in a new technology where rapid expansion has not waited for accumulation of experience. Mutatis mutandis, emission control devices tend to be blamed for higher gasoline consumption and, therefore, for shortages, when body weight, air conditioning and other add-ons, speed, and congestion are greater reducers of efficiency.

This is not to say that legislation during the 1960s, the administrative machinery now in place at the federal, state, and local levels, and the intervention of the courts have not significantly slowed the execution of energy-producing facilities; in this sense, the energy scene is probably the segment of the economy most heavily affected by environmental policies and considerations. But this is not the place to lay out the many areas involved, that tenuous chain of knowledge and reasoning, from emissions to ambient quality of air, land, and water, to impact on receptors, to quantifiable damage, to the relationship with benefits conveyed by the energy produced, transported, and consumed.

Since the national goal of "abundant, reliable, low-cost energy" must include in the cost column those costs external to the producer or consumer, the low cost is becoming a not-so-low cost. Safeguards, risk-reducers, delays, stopgaps, and less energy- or material-efficient routes add to cost. How far to carry these trade-offs is a matter of legitimate disagreement. Value judgments prevail, the more so as even the underlying data regarding damage attributable to environmental impacts are often in controversy. The effect of the resulting cost and price (or rate) increases on income distribution and on competitiveness of given industries or activities, in both domestic and foreign markets, is calculable up to a point, but what to do about them is a political decision. Questions abound. How safe is safe, and how costly is costly? To what extent are these researchable questions? And are they researchable only in terms of past human experience or with reference to some objective standard?

Frequently, the advice given in these matters is to act "prudently." How does society conform to the prescription? How far can we get with another generalization that explicates prudent to mean "preserving the maximum number of options"? Can society always know when it is foreclosing one? And how does it choose among options? The choice is hard enough when only technological alternatives are at issue: coal vs. nuclear energy, supertankers vs. pipelines, or power parks vs. plant dispersal. But comparison must also be made between benefits that accrue from abstention

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from action and the cost of shortfalls that might result, between this generation and the next, between this country and others. "Will Alaskan oil be kept in the ground," Senator Jackson asked in his July 9th press conference, "while the American people are running short?" How short is short? one wonders. What are the relevant costs? And who, by what means, is to bear them, one way or the other?

In a much broader framework and over the long run, the two questions are (1) how we can agree on the point up to which we wish to trade additional, or lower-cost, energy for environmental quality, and (2) in what proportion different groups in society will share the costs that inevitably flow from trade-off decisions, no matter where along the spectrum they are made. While considerable thought has been devoted to, and action taken on, the first, little thinking has gone into the second. To the extent that the cost increases pass through the price system, one may wish to limit action to areas outside the price system (via negative income taxes, for example, or other income-equalizing devices). Where regulatory processes are involved, however, overt decisions must be made, and it is harder to keep a hands-off attitude (hence, for example, the demand for the "inverted rate structure," though this may find justification quite apart from considerations here mentioned). Where domestic supplies are depressed in favor of imports, deleterious consequences by way of foreign exchange adjustments are probably too indirect and diffuse in their impact to allow compensatory policies to offset the damage to specific groups.

Low-cost energy has been an integral part of American economic history; but as the example of some European countries shows, comparable levels of per capita income can be reached with much lower per capita energy consumption. It is neither feasible nor rewarding to reconstruct America's history under hypothesized conditions of higher energy costs and lower levels of energy consumption. But it is feasible to contemplate with equanimity a prolonged period during which energy costs will be higher, utilization more efficient, and consumption patterns somewhat different, all without a profound sacrifice of welfare, though surely with temporarily painful adjustments and crisis-like phenomena. Possibly such a period may be followed once again by one of low cost and abundance of energy, if and when the technologies of either fusion or solar energy have been solved. Environmentally attractive and basically unconstrained by "fuel availability," solar energy would eliminate even the problem of excessive discharges of heat to the atmosphere; fusion might ease it. What new technological and environmental problems we might encounter we do not yet know; but experience has taught us to expect them. The first priority is to ease the energy problems now crowding in, and likely to be with us for some years at least and to do so in ways that will not obstruct long-term solutions.

THE YEAR'S WORK IN REVIEW

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A Summary of the Year

Once again, energy and environmental quality were the principal pivots of RFF research, but this time in the context of an acute national concern with immediate measures, and wider awareness of the long shadows cast by policy decisions. During the 1973 program year, RFF responded to the mounting crisis atmosphere in the manner most appropriate to a research institution — by intensified efforts to bring intellectual tools to bear on the array of problems. Management of residuals, energy conservation, offshore oil drilling, the atmospheric environment, wilderness and wildlife, coastal zone management, forest policy, nuclear power, and metropolitan governance are only a partial list of the interwoven issues dealt with in the careful and patient analytical process which alone offers society genuine advances. Examples of cooperative research programs with private and governmental institutions, both here and abroad, multiplied during the year. In each of RFF's major activities, fruitful results were made more likely through joining of hands on specific projects with interested agencies.

- U.S. energy supply options were the subject of intense study in a special program financed by the Ford Foundation as part of its Energy Policy Project. A report on energy research and development was prepared for use in the national fuels and energy policy study being conducted by the Senate Committee on Interior and Insular Affairs. Energy consumption trends and energy conservation opportunities in the New York City metropolitan region were the subject of joint research by RFF and the Regional Plan Association of New York. A seminar on energy modeling was held for scholars engaged in this field. A study to identify social science research needs in the energy field was undertaken at the request of the RANN program of the National Science Foundation. Work proceeded on a study of U.S.-Canadian energy trade. A major work on the world petroleum market was published. At the request of the Council on Environmental Quality, a report on problems of outer continental shelf drilling is in preparation.

- Major portions of RFF research in the quality of the environment reached, or were close to, completion. Three studies of residuals management in industry — aluminum, steel scrap, waste paper — were in finished manuscript form, while a fourth, on petroleum refining, appeared in book form. Two basic texts on environmental economics were in process of publication, as was a pioneering study of the political and institutional aspects of environmental policy. Books on the climatic and weather effects of energy conversion, and on air quality in the New York area were imminent; a volume on the economic and environmental aspects of the liquid metal fast breeder reactor program was in preparation. Work continued on regional residuals management modeling in connection with the Delaware Valley project. A conference on the economics of the environment was cosponsored by RFF and the Universities–National Bureau Committee on Economic Research at the University of Chicago.

- Representing a new direction in RFF's environmental quality work, several studies of "regions under stress" were commenced during the year. One is addressed to coastal zone management, involving cooperative research with the National Oceanic and Atmospheric Administration (NOAA) in its ecologically oriented study of the New York Bight Region. Another focuses on the tension between development and the environment in the Four Corners states of the Southwest. Companion studies abroad are expected to include the Mediterranean Basin and the North Sea.

- An extended seminar on national urban growth policy for selected members of Congress and their staffs was held in conjunction with the National Planning Association. Further work on metropolitan governance issues was undertaken in cooperation with the Academy for Contemporary Problems, and RFF's metropolitan governance research committee was reactivated. A grant from the National Science Foundation was received for research on structural changes in the regional and urban economy. Work on information resources was being readied for publication. Investigations into the quality of life and urban scale yielded new insights into such features as pay advantages and crime rates. A cultural analysis of American beliefs about real property was begun.

- In preparation for the forthcoming Third United Nations Conference on the Law of the Sea, RFF's program of international studies of fisheries arrangements completed several in a series of working papers concerned with particular fishery regions. Preliminary presentations of these reports were made at three international gatherings: the Asian-African Legal Consultative Committee in Delhi, the fourth annual *Pacem in Maribus* Conference in Malta, and summer meetings of the UN Sea-Bed Committee in Geneva. Two policy studies, a review of legal issues raised by the

National Environmental Policy Act, and an overview of resource and environmental issues, were completed. Two other studies, on land use planning and issues in forest policy, were under way. Further progress was made in the established resource appraisals project, and in special studies of resource adequacy.

- A cooperative research agreement with the U.S. Forest Service resulted in the design of a foot-traffic flow simulator for use by wilderness area managers in understanding the travel behavior of people using the wilderness. Another simulator, of wildlife population dynamics, was brought to operational state for use in wildlife management planning. A study of the economic management of migratory waterfowl was completed. Several studies of wild lands and water allocation were also completed. Synthesizing a five-year effort in the natural environments program, a major study of problems in allocating and administering public lands reached final draft stage. A pioneering volume on natural environments was published, based on papers presented at a workshop jointly sponsored by RFF, the University of Montana School of Forestry, and the U.S. Forest Service Forestry Sciences Laboratory at Missoula.

- A program of forest policy research has been undertaken to provide an improved analytical basis for forest activity in the United States. Through membership by an RFF staff member on the President's Advisory Panel on Timber and the Environment, a significant input was made to the panel's final report. Economic studies of the use of saline water for irrigation have yielded several professional papers. Two books on urban land use were published during the year, and a third study on national land use problems was commenced.

- A joint program of research on problems of water development and management was launched in Latin America. Financed by a two-year Ford Foundation grant, the activity involves university faculty in Mexico, Colombia, Chile, and Argentina. A study of water planning in Mexico undertaken for the World Bank was completed and delivered to its sponsor. An analysis of water resources managerial problems in the Mendoza region of Argentina was also completed. In Brazil, an RFF study of the sources of economic growth in twenty small- and medium-size cities in the state of Minas Gerais proceeded. Also in Brazil, RFF initiated and jointly sponsored (with CEDEPLAR and the Ford Foundation) a conference on urban economics and planning.

- Twelve grants, valued at $144,477, were made during the program year. Twelve fellowships, totaling $52,950, were awarded to doctoral candidates whose dissertations will deal with social science aspects of natural resources and environmental problems.

Thirteen theses by earlier recipients of fellowships were completed. Eight books were published and five others were in process of being printed.

STAFF. A number of staff appointments, resignations, and transfers in programs occurred during the year. In the energy and minerals program, Hans H. Landsberg was named the new director, to succeed Sam H. Schurr, who has accepted an appointment at the Electric Power Research Institute in California, as has Milton Searl; Mike M. Maaghoul completed his tour of duty, and Harry Perry was appointed consultant to this program. Edwin T. Haefele is the new director of the regional and urban program, replacing Lowdon Wingo, who has accepted the chairmanship of the City Planning Department of the University of Pennsylvania. New members of this program are Barry Schechter, from Northwestern University, and Constance Perin, formerly managing editor of the *Journal of the American Institute of Planners.* At the close of the program year, Anthony C. Fisher of the natural environments program left for a position at the University of Maryland. V. Kerry Smith, of the same program, completed his tour of duty with RFF and has taken a position on the faculty of the State University of New York, Binghamton campus. Replacing Fisher and Smith are R. Talbot Page, formerly working with the quality of the environment program, and Mordechai Shechter, of the Israeli Institute of Technology. Near the close of the year, Clarence J. Davies, formerly at the Council on Environmental Quality, joined the quality of the environment program to work on a study of environmental politics. Other new members of this program are John Hansen, formerly assistant attorney general in Vermont, and James W. Sawyer, formerly at the University of Pennsylvania. Thomas B. Cochran completed his work in this program and is now with the National Resources Defense Council. Boyd H. Gibbons came to RFF from the Council on Environmental Quality to work in the land and water program. Mason Gaffney of this program has accepted an appointment to the staff of the Institute for Economic Policy Analysis, University of Victoria, B.C. Other new staff members are Robert G. Healy, formerly with the Urban Institute, who is working on land use planning, and Leonard L. Fischman, who will be working on appraisals. Several changes also occurred in the publications staff: Vera W. Dodds retired as senior editor, and her position was filled by Joan R. Tron, former director of publications of the National Bureau of Economic Research. Two other long-term book editors, Nora Roots and Tadd Fisher, left during the year and were replaced by Ruth Haas and Margaret Ingram.

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Quality of the Environment

More than a decade ago, Resources for the Future began to study environmental quality problems, concentrating initially on water quality management. The substantial amount of theoretical and conceptual work that was accomplished through the later 1960s resulted in a number of important case studies. In addition, because considerable attention was given explicitly to public policy issues in the water quality area, the results of this research have been deeply influential in policy making in a number of countries.

By the middle of the 1960s, the staff had begun to think beyond water quality to the broader question of managing all the nonproduct materials and energy outputs from man's production and consumption activities. These nonproduct outputs, now referred to as residuals, are a major source of environmental degradation. They include airborne and solid materials, and energy, as well as waterborne materials. It became evident that these residuals ought to be studied as a group because of various interdependencies among them. For example, when wastewater is treated, solid or semisolid materials obtained from it are often incinerated, thus potentially contributing to air pollution. Conversely, in the treatment of stack gases a waterborne residuals stream is often generated because a wet-scrubbing process is used. Furthermore, the quality characteristics of inputs and outputs and the particular production processes used influence the amount and mix of residuals generated. A more systematic and coherent view of these interrelations was obtained through participation in a study of integrated waste management in the New York metropolitan region and through a considerable amount of theoretical work on the relation of materials and energy flows to basic economic theory.

Following these groundwork studies, the next major cycle in the quality of the environment program emphasized the broader problems of materials and energy flows in society, the factors that influence them, and means for their systematic and coherent management. The studies undertaken in this connection span the distance from basic theoretical work in economics and political theory through applied economic, technological, ecological, and political analyses of particular problems. While all the research

needed in the area of residuals management will not be completed for a long time to come, the current cycle of RFF work in this area will draw to a close during the coming year.

In the past year, major progress was made on a number of the component studies, including the large regional residuals management modeling effort (discussed in detail in previous annual reports), and several were brought to conclusion. Allen Kneese and Blair Bower have begun preparation of a "capstone" book aimed at summarizing and interpreting this cycle of research.

In this review of the year's work, we begin with some finished work on basic theory, proceed to a number of applied studies which were either completed or in which major progress occurred during the year, and finally discuss briefly some new directions toward which we are turning in our study of the quality of the environment.

BASIC THEORY

Building a solid structure of basic theory for its more applied studies is an enduring concern of the quality of the environment program. Accordingly, once the interdependencies of the various residuals streams became clear and the scale of the impact of residuals discharges on environmental media (common property resources) was evident, an effort was made to adapt the economic theory of resources allocation to these facts. Several persons were involved in this work in a major way, and a number of articles were written. A first pass at a reasonably complete statement of the revised and adapted theory appeared in the 1970 publication, *Economics and the Environment: A Materials Balance Approach*, by Allen Kneese, Robert Ayres, and Ralph d'Arge. This work wedded general equilibrium analysis from economics to principles of mass conservation from physics, and used the results to explain how the degradation of common property resources is tied to economic activities and economic development. This effort, containing some significant insights and innovations, gave rise to considerable further work by economic theorists, physicists, and ecologists. Among those who continued this approach and greatly extended it, as well as making it more rigorous theoretically, was Karl-Göran Mäler of the Stockholm School of Economics. At the close of the year, his manuscript, "Environmental Economics: A Theoretical Inquiry," was being edited for publication. It addresses the statics and dynamics of the new theory and applies the theoretical insights gained to problems of environmental analysis. When published, this study should be a standard work in its field for some years to come.

A textbook treating theoretical aspects of environmental economics, and of resources problems more generally, was in production at the close of the year. *An Introduction to the Economic*

Theory of Resources and Environment by the late Orris Herfindahl and Allen Kneese is being published by the Charles E. Merrill Publishing Co. The book reviews basic static and dynamic economic resources allocation theory and then treats a number of specific problems associated with resources use. These include primarily matters of resources conservation; the economics of public investment in resources, particularly water; and a variety of common property problems, such as those associated with oil pools, fisheries, and the various environmental media. The book is intended for advanced undergraduate and graduate students and presupposes a modest background in mathematics and economic theory.

MATERIALS FLOW AND MATERIALS RECYCLING

The approach to residuals problems developed at RFF can be stated by asking whether the rate of flow of materials through the economy is optimal, by some salient criteria; a corollary question is whether the rate of recovery and reuse of materials is appropriate. The quality of the environment program has launched a number of studies bearing on this problem. Three of the most pertinent ones are discussed in more detail below.

Incentives for Recycling

At the year's end, R. Talbot Page was preparing a draft manuscript of his study of incentives bearing on materials use questions. After a preliminary view of materials flows, including recycling flows, throughout the economy, Page focuses in detail upon the primary and secondary materials flows in the aluminum industry. In this industry example, quantitative estimates are made of the effects of freight rates and depletion allowances on materials flows. The "right" amount of recycling can be defined only in terms of criteria that discriminate among the various possible allocations of materials usage and depletion over time. Applying both the traditional economic criterion, which discounts future welfare, and the standards defined by conservationists, Page's study evaluates the present structure of freight rates, depletion allowances, other tax provisions, and various market failures which prevent the economy from recycling the right amount and which in general contribute to excessive use of materials. Some implications for changes in these policies are indicated.

Steel Scrap

At the end of the year, a report on recycling steel scrap from automobile hulks was completed by James Sawyer and was being revised for publication by RFF. The problem with this source of scrap is its quality, since automobiles contain other metals besides

iron, most notably copper, chromium, molybdenum, aluminum, and nickel. Except for some of the chromium and aluminum, these so-called tramp elements are not removed when scrap is melted during the steel-making process. As a result, the metallurgical properties of the resulting steel are changed, and its usefulness is substantially reduced, given today's product specifications. Sawyer's study describes various alternatives for processing de-registered automobiles to produce steel scrap for use as raw material concentrating on costs, scrap quality, and associated residuals generation. He has established a cost function for the reduction of the tramp element content of auto-based steel scrap. Using a model he developed for the study, he found that the short-run supply of auto scrap is very price-elastic; it depends heavily on collection and transportation technology and costs.

A particularly significant aspect of this study is its connection with the steel industry study being conducted by William Vaughan and Clifford Russell (see p. 66). At the end of the year, Sawyer, Russell, and Vaughan were working on linking the scrap model to the steel plant model to investigate such factors as steel product mix, furnace-type mix, level of relative ore and scrap transport charges, the severity of steel mill residuals discharge constraints, and the influence of these factors on the use of auto scrap and the fate of derelict auto bodies.

Waste Paper

During the year, Thomas Quimby and Blair Bower completed a study of the potential for increasing the recycling of newspaper and corrugated container residuals. Examining the relationships of paper recycling to the solid residuals handling and disposal system that operates in the Standard Metropolitan Statistical Area of the District of Columbia, they explored the outcome of alternative system arrangements. Solid residuals management costs were estimated for the metropolitan area at current levels and at alternative higher levels of recycling, and with alternative costs of unit operations. The authors paid particular attention to the effect of institutional arrangements on recycling, and found that substantially higher levels of paper residuals recycling appear economically feasible. Appropriate adjustments to achieve such levels require institutional arrangements and economic incentives.

Litter

The studies just described treat primarily those problems associated with relatively massive, concentrated residuals flows. Another major problem, however, is the small but injurious amount of solid residuals that become dispersed onto city streets and into the countryside.

During the year a grant was made to the University of New

Mexico to study the problem of dispersed solid residuals in the countryside. This includes litter in the ordinary sense of the term and also the important problems associated with open dumps and other inadequate disposal sites. It also includes automobile hulks, the indiscriminate disposal of which renders hideous the landscape of some of our most aesthetically charming, and recreationally valuable, countrysides. The principal researcher on this project is Lee Brown of the University of New Mexico's Economics Department. Several other economists and engineers are working with him. The study focuses primarily on the technology and costs of dealing with dispersed solid residuals and with institutional arrangements, such as collection systems for villages and the countryside and laws relating to automobile deregistration, which have a bearing on the efficiency and effectiveness of management alternatives. The Rio Grande Valley and its contiguous mountain areas are used for an illustrative case study. It is anticipated that a companion study on the urban litter problem will be launched by the RFF staff in Washington.

ECONOMIC INCENTIVES

To a great extent our environmental problems stem from the market's failure to generate the appropriate economic incentives for the use and conservation of common property resources. One way to correct this failure, although one much neglected in policy making in the United States, is to provide appropriate incentives through government action. This, of course, can only be done if the market failure is explicitly recognized.

During the summer of 1973 Charles Schultze of The Brookings Institution and Allen Kneese of the RFF staff began writing a manuscript on the use of economic incentives in environmental quality management. After a general discussion of the economic factors leading to environmental pollution problems, the study undertakes an extended review of the policies developed in the United States during the postwar period to deal with such problems. These policies have been heavily based upon direct regulation, enforcement, and the provision of subsidies for undertaking certain types of abatement actions. The policy review finds the approaches taken to be severely lacking when measured by standards of both cost and effectiveness. An alternative approach is to be presented, based heavily on the coherent use of economic incentives in the form of effluent charges and adjustments in tax policy, and on the development of competent regional planning and management agencies.

A closely related enterprise was launched in cooperation with the Environmental Law Institute. General leadership for this study was provided by Frederick R. Anderson of the Institute, with contributions by Serge Taylor of the University of California

at Berkeley, Russell Stevenson of George Washington University, and Allen Kneese. Although this study also looks at the problem of economic incentives as a policy tool, it gives primary emphasis to the practical aspects of implementation, including political, legal, and technological factors. It is expected that a manuscript reporting the results of this project will be completed in the spring of 1974.

POLITICAL AND INSTITUTIONAL ASPECTS

In the area of political and institutional aspects of environmental policy, Edwin Haefele has for several years taken a leading role in the quality of the environment program. During the course of the year, he finished compiling and adapting his essays and shorter studies in this field into a book, which is being published by RFF under the title *Representative Government and Environmental Management.*

Haefele also organized, concurrently with the annual meeting of the Public Choice Society, a conference on social choice and political activism. The purpose was to expose social choice theorists to some of the proposals for institutional reform being made by political activists, and to confront the activists with some of the consequences of their proposals. The program included the following presentations:

Allen Kneese, "A Critique of Environmental Legislation."
Mark Green, "The Need for Congressional Reform."
Charles Cicchetti, "The Use of Environmental Impact Statements."
Russell Stevenson, "Corporations and Social Responsibility."
Frederick Anderson, "The Use of the Courts in Environmental Actions."
Bowman Cutter, "The Use of TV by Political Actors."
Hazel Henderson, "Manipulating Information."
Clem Zinger, "Public Participation in Agency Decisions."
Daniel Mazmanian, "Federal Guidelines for Public Participation."
Paul Portney, "Benefit-Cost and Majority Rule."
John Jackson, "Airport Location: Who Decides?"
Henry J. Pratt, "The Logic of Collective Action in Activist Organizations."

Haefele is also continuing his work with the Delaware modeling team, whose activities are discussed below. In addition, he and Paul Portney are proceeding with their studies of alternative collective choice-making devices, including benefit-cost analysis, representative government, referenda, and the courts.

Near the close of the year, Clarence J. Davies, formerly of the Council on Environmental Quality, joined the quality of the environment staff and the regional and urban studies staff to

make an independent but complementary study of environmental politics. The questions he will be addressing include: How does a problem like environmental degradation become a public issue? What are the factors bringing it to the forefront of attention? What causes it to be displaced by other issues in the course of time? Why do other problems, perhaps as severe, fail to become national issues?

Within the area of institutional, including legal, studies, is the work undertaken by John Hansen, formerly assistant attorney general of Vermont, who joined the RFF staff near the close of the year to work with Clifford Russell. They will look into the legal and economic bases for environmental damage claims. Hansen approaches the subject through his experience as one of Vermont's trial lawyers in the International Paper Company case. There, the initial question has been whether Vermont has standing to sue for recovery of damages to its natural resources. It appears that the answer may be affirmative, but this then presents the problem of what measures of damages will be legally acceptable — both in terms of consistency with the law and, no less important, in terms of believability. Hansen and Russell have commenced research, which they hope will result in a methodology for legally acceptable damage estimation.

ENVIRONMENTAL EFFECTS OF ENERGY PRODUCTION AND USE

Perhaps the single most environmentally damaging human activity is the extraction of basic energy sources from nature and the conversion of these sources to energy for performing useful work. This set of activities generates a vast variety of unwanted by-products, including landscape disruption and discharge of particulate matter, sulfur oxides, and oxides of nitrogen to the atmosphere; it leads to the generation of highly hazardous fissile materials and, finally, to the rejection of the energy itself to various environmental media, ultimately the atmosphere. Four studies in the energy–environment area were finished by the quality of the environment program during the year and one was nearing completion at the end of the year.

Climatic and Weather Effects of Energy Conversion

William Frisken of the University of Toronto, while a visiting scholar at RFF, completed a study on the global and regional climatic and weather effects of energy conversion. His monograph, *The Atmospheric Environment*, was in press at the end of the year. It is a comprehensive, but relatively nontechnical, discussion of the natural phenomena involved and of what is known and not known about the various effects of energy conversion. Such conversion is, of course, not the only human influence on the climate

of cities and metropolitan regions. The forms and surfaces of the cities themselves have effects on the natural energy budget. These then interact in various ways with the actual emissions of materials and energy to the atmosphere. Frisken reviews and assesses the various models available for forecasting climatic and shorter-term atmospheric effects and points toward the research needed to improve our knowledge and ability to predict in this important area.

Nuclear Energy

Also completed during the year was a study of the economic and environmental aspects of the liquid metal fast breeder reactor program. The study by Thomas Cochran entitled *The Liquid Metal Fast Breeder Reactor: An Economic and Environmental Critique* was being edited for publication at the close of the year. Cochran makes a detailed assessment of the various issues bearing upon the desirability of rapid introduction of this reactor into the national energy economy. Reviewing the economic and conservation arguments put forward in favor of such rapid introduction, he finds many of them open to question. He then outlines and evaluates the various hazards known or thought to be associated with the fast breeder economy. These include large amounts of plutonium in the fuel cycle, the possibility of disastrous accidents, and the problem of long-term storage of highly radioactive waste materials. These problems are not unique to the fast breeder but are characteristic to some extent of any fission-based nuclear economy. In some cases, however, they take on a more severe form in the fast breeder economy.

Coal

Although coal has commanded a declining share in the national energy picture for some decades, the absolute amounts of energy generated from this basic resource are still very large. Coal is still the dominant source of electrical power generation. Furthermore, the recent interest in gaining self-sufficiency in energy resources will no doubt lead to considerably expanded efforts to exploit this most abundant of all conventional energy sources. Unfortunately, the adverse environmental effects of the coal-energy industry have been substantial in the past, and in some situations are relatively difficult to control. Jerome Delson, now of the University of Negev; Richard Frankel, formerly with the Asia Institute of Technology; and Blair Bower have done a detailed study of the environmental impacts generated in all stages of the coal-energy industry, from the basic extraction of the coal through its preparation, transportation and, finally, burning in the power plant. They have assessed available control technologies and studied the economics of simultaneous sets of environmental control on all stages of the industrial processes. They

have hypothesized alternative levels of successively stricter controls, analyzed the optimum (least-cost) ways of meeting them, and set out the costs involved. A revision of their manuscript, "Residuals Management in the Coal–Electric Energy Industry," was nearing completion at the close of the year.

Air Pollution

A manuscript that assesses some of the health impacts associated with air pollution resulting from energy conversion was completed and sent out for review. The focus is upon sulfur oxides and particulates, and the data concerning health effects are largely limited to mortality statistics. Lester Lave and Eugene Seskin, the former of Carnegie-Mellon University and the latter of the Urban Institute, performed careful and systematic statistical work on the limited and defective data available. They used many econometric techniques and introduced many variables to test the "robustness" of the apparent linkage between sulfur oxides, particulate matter, and levels of mortality in a cross section of cities across the country. They were also able to do a limited amount of time series work on particular cities. Their study led them to conclude that the relationship is real, and that the health impacts of these forms of pollution are large. [See essay, pp. 15–26.]

It is not just the overall damage from air pollution that is important, but also how that damage is distributed across the population. Jeffrey Zupan of the Regional Plan Association undertook to study some distributional aspects of air pollution under RFF sponsorship. His monograph, *The Distribution of Air Quality in the New York Region*, was in press at the end of the year. The report surveys several measures of the quality of the New York region's air — past, present, and future. Two hypotheses are tested: (1) the lower the income, the lower the air quality; and (2) programs to improve air quality tend to benefit the poor the least. In general, Zupan finds, the evidence tends to support both hypotheses.

OTHER INDUSTRY STUDIES

As mentioned in previous annual reports, a major area of study in the quality of the environment program has been residuals management in particular major industries. The coal-energy study is one example, but it stands somewhat apart from other studies completed or in process, in that it considers the whole process, from basic resource extraction through the production of final output, whereas the other research generally focuses on particular industrial plants. Two studies of the latter type have been completed and published: one for the beet sugar industry and the other for petroleum refining. The latter study, by Clifford Russell, was published during the program year under the title *Residuals*

Management in Industry: A Case Study of Petroleum Refining.

During the past year, a study of the steel industry, similar in concept to the petroleum refining study, was finished. It incorporates a linear programming methodology pioneered in the petroleum refining industry study, which includes residuals streams as well as marketable products. Programming models provide an extremely efficient device for estimating the costs of optimal responses to alternative sets of restrictions on residuals discharges. Several major papers were prepared on the steel study and were submitted to journals and other publications during the year. The technical information used in building and operating the model was reviewed during the summer and necessary revisions have been made. The first complete discussion of this study will appear as a dissertation by William Vaughan, who collaborated with Clifford Russell on the research.

The utility of, and some problems in, conducting such industry studies were discussed in a major paper by Blair Bower, "Studies of Residuals Management in Industry," presented at the Universities–National Bureau of Economic Research — RFF Conference on Economics of the Environment in November 1972. The paper described the evolution of the RFF industry studies, and of the results and their implications for residuals–environmental quality management policies.

THE REGIONAL MODEL

The industry studies have proved very useful in identifying technical opportunities for residuals management in industry and in the analysis of the economics of various possible control policies. In addition, they were designed to fit into regional residuals management modeling and analysis — the single largest component of the quality of the environment program. The regional residuals management model, which has been described in detail in previous annual reports, provides an integrative framework for many of the above studies, and is the tool for a coherent analysis of environmental policies on a regional basis. It takes full account of the interdependencies among the environmental media and the tradeoffs in production and treatment processes with regard to the generation and discharge of residuals.

An illustrative case study has been undertaken in the Delaware Valley by the modeling team of Walter Spofford, Clifford Russell, and Robert Kelly, with the assistance of Pathana Thananart, Louanne Sawyer, and James Sawyer. Their major activities over the past year have been to adapt the model to the particular region and to develop specific data needed to apply it there. At the end of the year preparations were being made to do full-scale production runs with the regional model. While the originality in the model consists chiefly of the point of view taken on the residuals prob-

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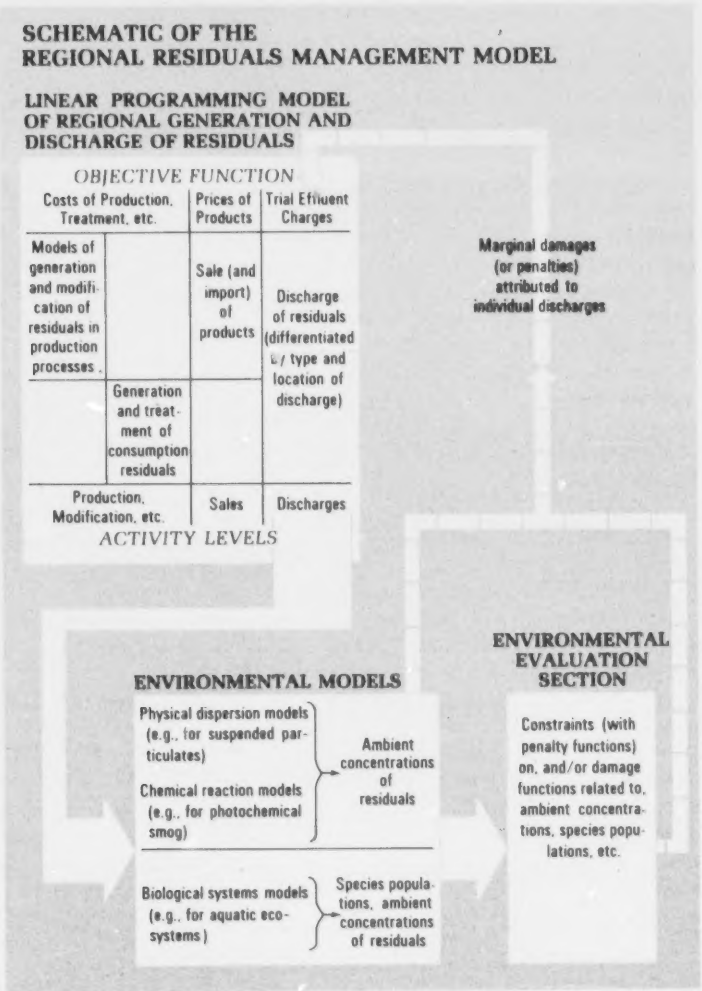
SCHEMATIC OF THE
REGIONAL RESIDUALS MANAGEMENT MODEL
LINEAR PROGRAMMING MODEL
OF REGIONAL GENERATION AND
DISCHARGE OF RESIDUALS
OBJECTIVE FUNCTION
Costs of Production, Treatment, etc.
Prices of Products
Trial Effluent Charges
Models of generation and modification of residuals in production processes
Sale (and import) of products
Discharge of residuals (differentiated by type and location of discharge)
Generation and treatment of consumption residuals
Production, Modification, etc.
Sales
Discharges
ACTIVITY LEVELS
Marginal damages (or penalties) attributed to individual discharges
ENVIRONMENTAL MODELS
Physical dispersion models (e.g., for suspended particulates)
Chemical reaction models (e.g., for photochemical smog)
Ambient concentrations of residuals
Biological systems models (e.g., for aquatic ecosystems)
Species populations, ambient concentrations of residuals
ENVIRONMENTAL EVALUATION SECTION
Constraints (with penalty functions) on, and/or damage functions related to, ambient concentrations, species populations, etc.

The schematic above appeared in a recently published RFF monograph, Residuals Management in Industry: A Case Study of Petroleum Refining, *by Clifford S. Russell. It is intended to show how industrial and environmental models of residuals management fit into an overall regional model. The residuals generation and discharge submodel is intended to optimize prices, costs, and trial values of effluent charges. The discharges are routed through the physical, chemical, and biological submodels to measure such environmental factors as the amount of SO_2 in the atmosphere, fish populations, and other pertinent variables. These measures are then evaluated in the section containing constraints and/or damage functions, where the damages or penalties assignable to each discharge are calculated. These costs are then applied as trial effluent charges to their respective discharge activities, and the generation and discharge submodel is solved again.*

lem and the interlinkages of the various subcomponents, one truly major new feature is a nonlinear submodel of the ecosystem of the Delaware Estuary, which was constructed by Robert Kelly. Walter Spofford worked with him in adapting the ecosystem model for use in the larger optimization model. This is quite different from the conventional linear models, which forecast dissolved oxygen concentrations as a function of only organic materials discharges; it includes discharges of other residuals, such as phosphates and toxics, which have impacts on living populations, such as phytoplankton and fishes.

An important step in the development of the overall model was reported in a major paper by Russell, Spofford, and Kelly entitled "Operation Problems in Large-Scale Residuals Management Models," presented at the Universities–NBER — RFF Conference on Economics of the Environment in November 1972. A base model offered in this paper included the nonlinear ecosystem model of the Delaware Estuary, along with discharge control models for several Philadelphia area industries. Essentially, this step in the overall regional modeling research plan represented the first real test of the optimization routine developed to allow imposition of ambient quality constraints when the natural world models are nonlinear. The base model is the cornerstone upon which the full-scale Delaware Valley model is being constructed.

The nonlinear aquatic ecosystem model itself is described in considerable detail by Kelly in "Conceptual Ecological Model of the Delaware Estuary," to be published in Volume IV of *Systems Analysis and Simulation in Ecology*, B. C. Patten, ed. A discussion of the mathematical structures of various air and water quality models and how the different kinds of models can be included within an optimization framework is found in Spofford, "Total Environmental Quality Management Models," published in R. A. Deininger, ed., *Models for Environmental Pollution Control* (Science Publishers, Inc., Ann Arbor, August 1973).

Work on the final large-scale version of the Delaware Valley model proceeded actively during the year. Petroleum refinery and steel mill models, based on the industry studies discussed above, have been created for each of the major plants in the region. Discharge control models for each of the power plants in the region were also constructed. Less detailed linear programming models for other major point sources in the region were built, based on secondary information available from the Environmental Protection Agency. Some consumer residuals are also included in the model, and work progressed on a paper recycling, solid residuals management model. Solid residuals management options for fifty-seven political jurisdictions in the model include incineration, landfill operations, rail haul, generation of steam, and paper recycling. When completed, the outputs of the model will be specifically keyed to the fifty-seven equi-population political jurisdictions. These outputs will include variables not only of environmental

quality but also of cost distribution, in order to provide a basis for political trading in an associated model of collective-choice making developed by Edwin Haefele. The intent here is to examine how alternative political structures — for example, representative government based on small political jurisdictions vs. Councils of Government (COGs) — will affect outcomes, in terms of both levels of environmental quality selected and the distribution of cost and benefit.

As is to be expected, many practical operational questions arise in the construction of a large complex model such as that of the Delaware Valley. An important one that was addressed and resolved during the year concerns how the vast number of individual point sources of air emissions could be aggregated without losing too much accuracy. Criteria were developed for aggregating a group of stacks, all located at the same plant, and for determining the characteristics of a single representative stack for each plant.

The operational Delaware model will permit testing hypotheses about how important it actually is to take explicit account of all environmental media simultaneously in a regional setting; it can be used to establish coherent sets of environmental controls and to establish a firm basis for the estimation of overall costs of these alternative sets; and, when combined with the political model, it can provide insights into which kinds of mechanisms for making collective choices come closest to reflecting the preferences of affected populations.

Another attempt to apply the residuals-environmental quality management framework was initiated this year under a grant to The Johns Hopkins University. The focus of the study is the Ljubljana area of Yugoslavia. The principal investigator is Jack C. Fisher of the Center for Metropolitan Planning and Research at the University. The study is being undertaken with the cooperation of the Urbanisticni Institut SRS in Ljubljana.

OTHER ACTIVITIES

Conference

The new field of environmental economics has grown and prospered sufficiently so that it has in the past few years supported several major conferences. In November 1972 the Universities–National Bureau Committee for Economic Research and Resources for the Future joined forces to sponsor one such conference, which was held at the University of Chicago. The conference was planned by Edwin Mills of Princeton University, Otto Davis of the Carnegie-Mellon University, and Allen Kneese. The conference volume, to be published jointly by NBER and RFF, is edited by Edwin Mills and will be entitled *Economics of the Environment*. Papers presented at the conference were as follows:

William Baumol and Wallace Oats, "The Instruments for Environmental Policy."
George Tolley, "Choice of Tools in Environmental Problems."
Robert Kohn, "Input-Output Analysis and Air Pollution Control."
Walter Spofford, Clifford Russell, and Robert Kelly, "Operational Problems in Large-Scale Residuals Management Models."
Ralph d'Arge, "Observations on the Economics of Transnational Environmental Externalities."
Maynard Hufschmidt, "Alternative Approaches to Environmental Quality Management: Observations on Recent Experience in Europe and the U.S."
Blair Bower, "Studies of Residuals Management in Industry."
Lester Lave and Eugene Seskin, "Acute Relationships among Daily Mortality, Air Pollution, and Climate."
Hirofumi Uzawa, "Optimum Investment in Social Overhead Capital."
Karl-Göran Mäler, "Macro-Economic Aspects of Environmental Policy."

Foreign Visitors

In the course of a normal year, RFF is host to a number of visting foreign scholars. During this past year the quality of the environment program was fortunate in having three distinguished foreign scholars visiting with the staff and participating in various staff activities.

Professor Horst Siebert of the University of Mannheim spent several months at RFF reviewing the program's work and acquainting himself with environmental issues and policies in the United States. The results have been several publications in German, including a review of the American literature and a book, *Das Produzierte Chaos* (Verlag W. Kohlhammer, Stuttgart), which provides a broad and detailed treatment of environmental economics for German readers.

Dr. Giuseppe Sacco of the University of Siena spent the summer at RFF with a similar purpose. Seminars and discussions with the staff led to plans for a study of the environmental aspects of oil shipments in the Mediterranean as a function of such considerations as opening the Suez Canal and variations in American policy. The vast bulk of world oil shipments occurs in the Mediterranean, and that smallish body of water is already heavily polluted with petroleum. It is expected that Dr. Sacco will pursue this study when he returns to Italy in early 1974.

During the summer, Karl-Göran Mäler of the Stockholm School of Economics spent several weeks at RFF with the quality of the environment program. The main reason for his visit was to work closely with the editor in putting final touches on his manuscript (see p. 58). While available, he gave several seminars, including one on environmental issues in the Baltic.

In addition to the intrinsic interest of the environmental problems of the Baltic and the Mediterranean, study of these problems by the staff and visiting scholars reflected a new direction in RFF environmental studies.

NEW DIRECTIONS

Up to this time, the quality of the environment program has focused rather specifically on the issues associated with residuals management. It has largely avoided addressing questions of landscape aesthetics and land use policy. It has also neglected probing study of resource commodities, unless their relation to residuals management questions was very close. Partly to permit a more comprehensive view of the resources–environment–human activities complex, and partly because specific types of regional situations have assumed great importance in economic development and environmental policy making, members of the program are developing initiatives in the direction of several "regions under stress" studies.

Among such regions are the coastal zones. They contain the bulk of the national population; their amenities and recreational opportunities are very important; they have intense and peculiar environmental problems; and they have been the subject of recent national legislation. An early RFF study in this area was a paper prepared by Clifford Russell and Allen Kneese for presentation at a National Oceanic and Atmospheric Administration conference in Washington State during July 1973. The paper, "Establishing the Scientific, Technological, and Economic Basis for Coastal Zone Management," stressed the importance of coastal zone problems, tried to distinguish those which are unique to the coastal zones and those which are universal where common property resources are important, and presented several conceptual models for the study of particular coastal zone problems. This paper is scheduled for publication in the new *Journal of Coastal Zone Management.*

An activity that reaches further back in time is the RFF staff's work with National Oceanic and Atmospheric Administration (NOAA) personnel on the development of marine ecological system programs. Partly because of this effort, NOAA established its ecologically oriented study of the New York Bight Region. Quality of the environment staff members are assisting NOAA in developing conceptual models for this enterprise, especially in the direction of making its outputs suitable for inclusion in more management-oriented models. We expect this cooperative enterprise to continue and possibly grow into a full-scale management study under RFF auspices. The Delaware modeling team will take the major role in this. Initiatives are also being taken to develop companion studies abroad. As mentioned, plans are being laid for Guiseppe Sacco to study environmental problems in the Mediter-

ranean Basin, and discussions are underway with the University of Louvain to extend a large ecological study of the North Sea in the direction of defining and analyzing management options.

Another "region under stress" which the quality of the environment staff intends to study is the Southwest. This is defined to consist of the "Four Corners" states of Arizona, Utah, Colorado, and New Mexico but also, for certain purposes, to include Wyoming and Montana. This region contains most of the remaining conventional energy supply in the United States, and several unconventional sources in this region, such as solar and geothermal, are of potentially great importance. This region is also of major interest because it is relatively unspoiled, greatly valued for its amenities and recreational opportunities, but is ecologically very delicate. The conflict between development and environment takes a particularly stark form here, and the matter of properly managing development has great urgency. In addition to the complex of questions concerning land use, energy, environmental, and economic development, this area contains the last remaining native American populations with high cultural integrity, as well as a substantial Spanish-speaking minority. The sociological circumstances of both these peoples are closely tied to resource and environmental issues.

An opening initiative in the RFF study of the Southwest was to ask Roger Hansen, Director of the Rocky Mountain Center on Environment, to study the legal and policy situation with respect to mining in the region. He will do a comparative analysis of laws in the several states and at the national level, including those, such as tax laws, which have indirect incentive effects on mining operations. Discussions are proceeding with other scholars in the region on various facets of the issues discussed above. It is expected that Allen Kneese will take a leading role in this RFF study when he moves to the University of New Mexico in the summer of 1974.

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Natural Environments

About 80 percent of the land mass of the United States has come under private ownership. This land has been used predominantly to support the sites of human residences, transportation networks, and extractive activities to supply an urban-industrial economy. Of the remaining 20 percent in public ownership, a large part also serves as a source of mineral and forest products. Indeed, of the total land area in the coterminous United States, only about 50 million of the original 2 billion acres remain sufficiently undisturbed by man's economic activities to qualify for potential inclusion within the National Wilderness and Wild and Scenic Rivers Systems under terms of the legislation establishing them. Currently, less than six-tenths of 1 percent of this land exists in the statutory wilderness system, with perhaps another 2 percent under review. This review will determine whether the land will be used to supply raw materials for industry or reserved for recreational and environmental uses. The two dispositions are not usually compatible.

The task that public land management agencies face in administering these lands for maximum benefit is complicated by the nature of some of the sites. Some natural environments are irreplaceable. If they are allocated a use that modifies or destroys them, they cannot be returned to their original state and thus may be permanently precluded from other uses. Although some of the country's natural areas with special features enjoy statutory protection and are not subject to exploitation for their resource commodities, much of the undisturbed natural environment remaining on public lands faces, in varying degrees, the possibility of being transformed through reallocation — often without thorough analysis of the relative values attaching to the alternative uses. If the hundreds of public land use cases which will require attention over the next decade are to receive the kind of analysis they deserve, public land management agencies should have adequate means for considering choices that involve, in many cases, destruction of irreproducible assets.

The natural environments program at Resources for the Future has been directed toward methodological issues that arise when choices need to be made among alternative uses of remaining natural areas. The preservation of such areas for uses compatible with the continued existence of their natural states is of course one of the alternatives considered. In the first phase of the program, nine major research undertakings addressing these issues were completed, and preliminary results were reported and discussed at a workshop held in collaboration with the Forest Sciences Laboratory of the U.S. Forest Service and the University of Montana. A book based on the workshop report, entitled *Natural Environments: Studies in Theoretical and Applied Analysis*, edited by John Krutilla, was published during the program year. Also published was a study, by Charles J. Cicchetti, of the environmental implications of raising and transporting to market Alaskan North Slope oil, entitled *Alaskan Oil: Alternative Routes and Markets*. Cicchetti, who left RFF in the summer of 1972 to join the staff of the University of Wisconsin, also published a monograph entitled *Forecasting Recreation in the United States* (Lexington Books, D C. Heath and Co.), which reviews the use of economic methods in recreation planning and illustrates the application of a forecasting model that can be used for outdoor recreation planning. He was coauthor, with Anthony C. Fisher and V. Kerry Smith, of a paper appearing in *Operations Research* entitled "Economic Models and Planning Outdoor Recreation."

Uncertainty and Environmental Policy

A group of studies were completed which involved the problem of choice under conditions of uncertainty in the allocation of wild lands and water. These studies also considered the appropriateness of discounting costs, as well as the discount rate to be applied in decisions involving environmental modifications, and the implications of technological change for choice between incompatible alternative uses of irreplaceable assets. The results of these studies were accepted for publication either by RFF or professional journals.

An important aspect of the theory of optimal allocation of environmental resources concerns the choice between preservation and development of natural environments under conditions of uncertainty. Uncertainty affects even our best estimates of future benefits and the cost of alternative uses of environmental assets. Kenneth Arrow and Anthony Fisher, in a study concerned with this problem, conclude that uncertainty about costs and benefits reduces the expected value of a development having irreversible consequences for the environment. This implies that, even assuming perfect neutrality with respect to risk, less of a given natural

area should be modified than would be optimal if all of the costs and benefits were known. If there is aversion to risk, this conclusion applies with increased force. The results of the Arrow-Fisher study will appear in a paper accepted for publication by the *Quarterly Journal of Economics.*

The Rate of Discount

The rate at which future costs and benefits associated with investments are to be discounted — particularly those in the public sector or involving environmental resources — has long been of interest to students of welfare economics and benefit-cost analysis. The study by Anthony Fisher and John Krutilla, which was reported on in last year's annual report, has been completed and a paper based on it is being published in the *Quarterly Journal of Economics.*

Effects of Technical Change

The effects of technical innovation on the changes in values of services from environmental resources, relative to other goods and services, have been under study by V. Kerry Smith, as described in last year's annual report.

The results of the general investigation have been made available in several publications. Two of these are: "A Review of Models of Technical Change With Reference to the Role of Environmental Resources" *Socio Economic Planning Science,* and "Relative Prices, Technical Change and Environmental Resources," *Natural Resources Journal.* Related papers have appeared or are scheduled to appear in forthcoming journal issues. Included among these are "The Implication of Common Property Resources for Technical Change," in the December 1972 issue of the *European Economic Review,* and "Environment, Needs and Real Income Comparisons: A Suggested Extension," in the *Review of Income and Wealth.* A major monograph in which the principal findings are integrated was accepted for publication, and the manuscript was undergoing author's revisions at the end of the program year.

Economic Management of Migratory Waterfowl

Although much research has been devoted to the efficient allocation of land for agricultural purposes, little has been done on the allocation of land for recreational purposes involving wildlife. Over a million individuals annually hunt, view, or photograph migratory waterfowl, yet most of the nesting and resting habitats of migratory waterfowl occur on private lands devoted to the production of agricultural commodities. On such land, no explicit attention is given to services that would provide for the maintenance of a population of waterfowl. Gardner Mallard Brown and

Judd Hammack have completed a study that addresses this problem.

They begin with a theoretical model that yields an estimate of the marginal value of waterfowl to hunters. They then formulate a model for determining the optimal levels of waterfowl breeding populations and nesting ponds, subject to the dynamic constraint of population growth as affected by human predation. Optimal levels are those that maximize the present value of the difference between recreation hunting benefits (the hunters' consumer surplus), as developed from the imputed demand schedules, and the cost (in terms of foregone agricultural opportunities) of the breeding ponds. An application of this analysis to the question of wetlands allocation suggests that the observed number of breeders and breeding ponds has been less than optimal in recent years.

Summary results of this study were published in an article entitled "Dynamic Economic Management of Migratory Waterfowl," in the *Review of Economics and Statistics*. A full-length monograph on the research is currently being revised by the authors.

Population Dynamics of Wildlife Management

Resources mangement implies an effort to find the optimal mix of outputs that can be provided by a combination of resources under a manager's control. This should be no less true of the management of wildlife resources than of other resources. Under a grant from RFF, Jack Gross of the University of Colorado has been working on a wildlife population dynamics simulator. This will mimic the behavior of ungulate populations in response to perturbations imposed by hunting and related regulations under the control of the wildlife manager. The simulator will play out the consequences of a postulated (or proposed) change in regulations for all of the system performance criteria and in this fashion check for consistency between proposed changes and management objectives. For example, it is possible to determine whether a change in regulations, such as harvesting a given number of male or female animals, will maintain the desired age-sex composition of the breeding stock. These are measures of performance — or potential objectives of management — that are intricately related through population dynamics. The state of the system in all of its interrelated attributes is not intuitively obvious after it is subjected to some change in one or another of its governing factors. Thus the simulator provides a management tool that permits "experimenting" with different postulated practices or policies to evaluate the consistency of their results with all management objectives, or the trade-offs involved.

At the end of the program year the simulator was operational and could be used in wildlife management planning. Exploratory discussions with behavioral and social scientists were conducted with the thought that ecological research on wildlife population

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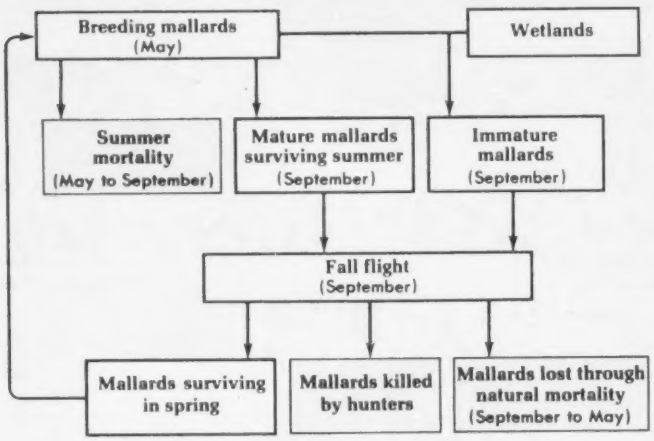
FLOW DIAGRAM FOR THE CONTINENTAL MALLARD POPULATION


Breeding mallards (May)
Wetlands
Summer mortality (May to September)
Mature mallards surviving summer (September)
Immature mallards (September)
Fall flight (September)
Mallards surviving in spring
Mallards killed by hunters
Mallards lost through natural mortality (September to May)

As the chart illustrates, only a fraction of mallards breeding in May will survive to September. These birds and their offspring form the fall flight. A number will be killed (although not necessarily bagged) by hunters. Of the remainder, only a small percentage survive nature's vicissitudes to return to the breeding grounds the following spring. The role of the continental wetlands in this cycle is the subject of an RFF-sponsored study by Judd Hammack and Gardner Mallard Brown, Jr., entitled "Waterfowl and Wetlands: Toward Bio-Economic Analysis," from which this diagram is reproduced.

dynamics could be supplemented by complementary research in the human behavioral sciences. Such research would assist the wildlife manager in determining the clientele groups, or "markets" for his resource services and the preference structure among the members of each group.

Low-Density Outdoor Recreation Resources

Regardless of the amount of roadless wild area that may be added eventually to the statutory wilderness system, the indicated demand will in time exceed the supply unless congestion of a degree incompatible with retaining the wilderness character of the areas is permitted. The question then arises as to how many people one can admit to a wilderness area during any interval of time and still retain the character of the area consistent with the intent of the Wilderness Act of 1964. This problem received early

attention by Fisher and Krutilla in cooperation with the Forest Sciences Laboratory of the U.S. Forest Service Wilderness Research Project, Missoula, Montana (see the 1971 annual report, p. 43). In a paper entitled "Optimal Recreation Capacity for Resource-Based Recreation Facilities" (*Natural Resources Journal*), a conceptual framework for identifying the recreational carrying capacity of wilderness areas was presented. Later, Cicchetti and Smith, in cooperation with Robert Lucas and George Stankey of the Wilderness Research Project, U.S. Forest Service, developed measures of the reduction in marginal benefits per recreation day in the wilderness as the expected frequency of encounters increased. Their results were published in *Social Science Research* in a paper entitled "Congestion, Quality Deterioration, and Optimal Use: Wilderness Recreation in the Spanish Peaks Primitive Area." A more complete treatment of monograph length was near completion at the end of the year.

Wilderness Traffic Simulator

In addition to being able to measure the decline in marginal benefits as the expected frequency of congestion in the wilderness increases, the wilderness area manager must have the means of estimating the expected frequency of personal encounter as intensity of use increases. With this need in mind, a traffic flow simulator which mimics the travel behavior of individuals using the wilderness was developed by Charles Cicchetti, John Krutilla, and V. Kerry Smith with the programming assistance of David Webster and Norman Heck, a team of IBM analyst-programmers. The effort was part of a cooperative research agreement with the U.S. Forest Service.

The model has the ability to represent, with the appropriate data, any low-density recreational area. It simulates the behavior of the users of the area over preassigned time periods and records the characteristics of each party's experience while using the area. Great flexibility in the design of the program allows the user to alter the travel patterns, total use, time scheduling, and the configuration of trails in order to evaluate alternative policies. By the year's end the program and user manual were available. Moreover, a variety of simulation experiments had been performed with a small prototype model. Some of these results are available in "A Prototype Simulation Model of a Wilderness Area," SUNY Binghamton, Economic Growth Institute, Paper No. 8.

With the beginning of the new academic year, V. Kerry Smith moved to a position as associate professor of economics at the State University of New York at Binghamton. A grant of $10,250 was made to the University to support continuation of Smith's work, which applies the simulator to the evaluation of the effects of alternative management options on the quality of wilderness recreation experience in the Spanish Peaks Primitive Area of

Montana. Policy options include restriction on the time distribution of users such as advance registration might entail, alterations in the probability of route selection by parties, changes in the total intensity of use, change in the mix (backpack or horseback) of users, potential changes in the trail system, and a variety of other nonprice and investment strategies. The results will complement work Smith completed while at Resources for the Future and will be incorporated into a monograph he is preparing jointly with John Krutilla.

Plans were being developed to hold several workshops with Forest Service research and management personnel to field test the simulator and carrying capacity models during the final phase of the work on the "congestion/carrying capacity" project.

ALLOCATION OF ENVIRONMENTAL RESOURCES

As the end of the first five-year effort in the natural environments program was approaching, Fisher and Krutilla were preparing a synthesis of work undertaken in the program. The study primarily addresses the matter of allocating and administering public lands which represent what is left of the major U.S. natural scenic resources, along with certain associated common property resources. On the theoretical side, the study is concerned with developing criteria for evaluating alternative uses of these natural and environmental resources, and determining their optimal allocation over time. The work encompasses the range of amenity resources which, while long recognized (and to a great extent honored in public policies that provide for national parks, national wildlife refuges, and the National Wilderness System), have not been explicitly incorporated into the body of economics and, hence, into the theory and practice of resource allocation. In this respect, the undertaking is a "first generation" effort designed to incorporate environmental amenities into resource allocation and management analyses. The theoretical considerations provide a framework for empirical analyses, which, it is hoped, represent for public land managers prototypes of a number of currently important cases in which competing uses are at issue.

At the conclusion of the program year, the manuscript was being reviewed preparatory to final revisions.

Land and Water

During the year, new research on forest policy was begun, and numerous conferences, seminars, and professional papers brought the results of past research to a growing body of the public interested in land use. Two books, described in last year's annual report as then in press, were published, and four grants for research projects on various aspects of land use were made.

Urbanization in the Washington Metropolitan Area

During the program year, a grant was made to American University for a study of the legal and operational aspects of urbanization in the Washington metropolitan area. Specifically, Barlow Burke, Jr., principal investigator, and his students have been examining the history of a large number of zoning and rezoning cases in Montgomery County, Maryland, and in Fairfax County, Virginia. Of particular interest is the role and attitude of the courts, the role of the bar, and the activities of lawyers specializing in land use cases. These were examined both from the public record and by interview with some of the leading practitioners. The interrelationships among planning agencies, developers or builders, and lawyers were studied in a number of ways.

The results of this study will be particularly useful to lawyers, but valuable also to land planners who have the interest and ability to study the legal aspects of land planning. A report on the project, which was both begun and completed within the program year, was filed with RFF and placed in the library at American University for use by students.

Handbook on Suburban Land Planning

A grant was made to the League of Women Voters during the program year to prepare a handbook for its members and associated organizatio s on suburban land planning, particularly the exclusionary aspects of much suburban land planning and zoning. The League has been much concerned with suburban exclusionary land zoning, and has undertaken a considerable program of fact-finding and information dissemination to local Leagues and other

groups concerned with the problem, leading to a national conference held in early 1973.

The RFF grant was made specifically for the purpose of helping the League prepare a handbook on this subject, similar to the RFF grant made in 1963 for a handbook on water planning problems and issues. The suburban land planning handbook, when completed, will be published by the League and widely disseminated.

Structure and Function of Market for Southern Forest Resources

A small grant was made to Washington and Lee University during the program year to study the structure and functioning of the market for Southern forest products, particularly pulpwood. The market for pulpwood is believed to have unusual characteristics because most paper manufacturing companies in the South produce some of the wood needed for their mills and also buy some. Wood, being a relatively heavy raw material in relation to its value, often has a local market, one not fully competitive in the economic sense of the term. In particular, buyers of wood in each area are relatively few and, in buying wood, each must be acutely aware of the effect of his purchases upon the market price for the whole area.

S. Todd Lowry, the principal investigator, and his students interviewed a number of wood processors, buyers, and growers in selected Southern areas in the spring and early summer of 1973. The project has not yet reached its final stage, but a publishable report or article is expected.

Federal Resource-Managing Agencies

A small grant was made by RFF to Northwestern University during the program year, to enable H. Paul Friesema, a professor at the University, and Paul J. Culhane, a graduate student, to further their analysis of federal resource-managing agencies. The grant will be used by the researchers to conduct field interviews in the Black Hills area of South Dakota, to determine how federal agencies reacted to the flooding of that area in 1972. This work is part of a continuing analysis of federal resource-managing agencies undertaken by Friesema, who was the recipient of a similar RFF grant a few years ago for a study of New Mexico.

Forest Policy Studies

During the program year Marion Clawson devoted a significant proportion of his working time to the President's Advisory Panel on Timber and the Environment, a special panel of five members, established by executive action in September 1971. The Panel report, which was publicly released on September 24, 1973, was concerned with the supply of lumber, plywood, and other construction materials originating from the forest, and with the rela-

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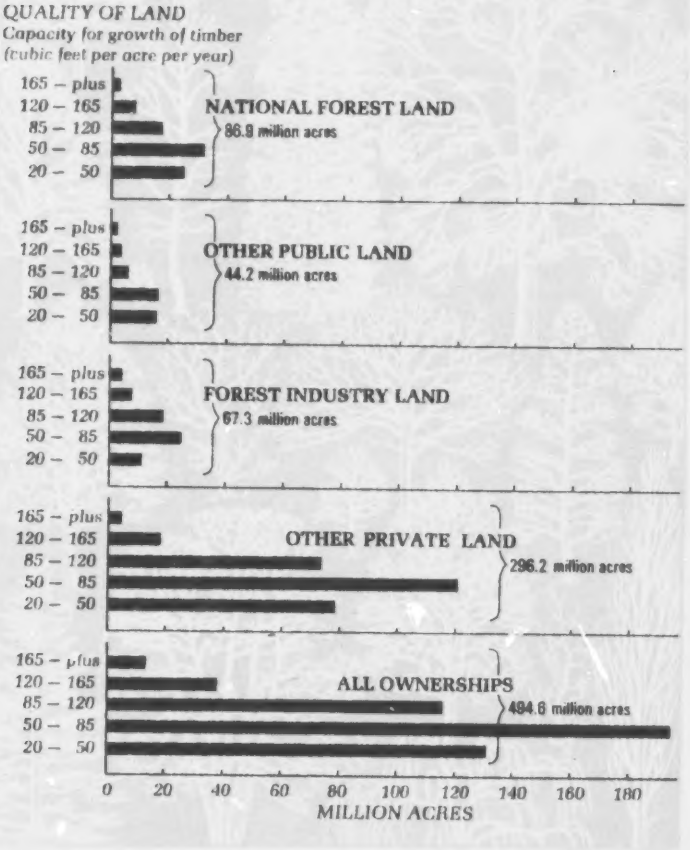
AREA OF COMMERCIAL FOREST LAND BY OWNERSHIP CLASSES AND SITE QUALITY



Commercial forest land represents about two-thirds of the nation's 754 million acres of forests. The total area of commercial forest land constitutes slightly more than a quarter of the land area of the contiguous United States. Commercial forests substantially exceed the area of land used for crop production, even when cultivated pasture is included. Two facts stand out when the data in this table are further analyzed: 1. There is a wide range in productive capacity within each ownership class; no ownership class of forests has all the most productive forests, none has all the least productive ones. 2. The distribution of land area among the site classes differs greatly from the distribution of productive capacity. (Site class is a measure of the capacity of forest land to grow timber; the rate of tree growth is of course affected by climate, soil, and the associated fauna and flora of the site.)

tionship between production of such materials and the forest environment. The report makes a number of specific recommendations on environmental and timber supply matters, presenting an excellent review of the forest situation in the United States, and outlining suggestions for management of forests, both publicly and privately owned. As a result of Clawson's activities on this panel, RFF has begun work on a program of forest policy research, to provide a better analytical basis for forest activity in the United States.

Upsurge of Interest in Land Use, and Its Impact on RFF

The past two or three years have seen an upsurge of interest in land use and in land policy. A number of studies have been made by public agencies or commissions, by semipublic organizations, and by private parties. Proposals are pending in the Congress for federal legislation on land use planning. Many states have either enacted legislation, or conducted major studies, or otherwise shown a major interest in land use. The rising price of land, and of real estate generally — both rural and urban — has focused popular attention on land use and its control, including land for urban, suburban, agricultural, forestry, and recreational uses.

This heightened interest in land use has had a parallel in RFF research. Over the past several years a number of studies have been made by RFF staff, or under grant from RFF, resulting in the accumulation of a considerable body of published research on one or another aspect of land use in the United States. Members of the staff are actively sought after, nationally and internationally, to present ideas and facts about various aspects of land use. The list of "selected activities" and of selected papers published in this report (pp. 126–37), gives some indication of the range and volume of such staff concerns. While these activities are not research in the older sense of that term, they do add to the knowledge and understanding of the RFF staff members concerned, providing a major extension of the utilization of past RFF research beyond that which the published books alone could achieve. Indirectly, such activities may have a significant effect upon land policy, perhaps greater than could be expected from a similar expenditure of time in research more narrowly defined and more conventionally published.

At the end of the year, Boyd H. Gibbons III transferred from the staff of the Council on Environmental Quality to Resources for the Future in order to prepare a book on national land use problems and alternatives.

Modernizing Urban Land Policy

If cities are to be developed or rebuilt to serve a broader constituency, there must be both procedural and substantive improve-

ment in many urban land programs and better coordination of public and private actions.

As described in last year's annual report, a public forum on urban land policy was held at RFF in April 1972 to discuss such difficult questions as land use controls and the costs they impose on minority groups; legal questions; and how environmental concerns must be balanced against concern for the disadvantaged.

The volume, *Modernizing Urban Land Policy*, that resulted from this forum was published during the program year. The final chapter, written by Marion Clawson, the editor of the volume, and Harvey S. Perloff of the University of California at Los Angeles, sums up the alternatives available and recommends policy lines to follow in the future.

Planning and Urban Growth

The difficulties and complexities of guiding urban growth, and the real danger that unwise efforts may worsen the situations they are designed to correct, are explored in considerable depth and detail in the newly published, *Planning and Urban Growth: An Anglo-American Comparison*, by Marion Clawson and Peter Hall. Perhaps the most important conclusion emerging from this book, which was described in detail in last year's annual report, is that the results of urban planning are not always those which were intended, nor are the real results always those which a superficial examination would suggest.

Studies of Water Use

Dan Yaron and his associates at the Hebrew University, Israel, have for some years conducted economic studies on the use of saline water for irrigation, under grant from RFF. During the program year two professional papers presented results of this research: "Economic Analysis of Optimal Use of Saline Water in Irrigation and the Evaluation of Water Quality," by Dan Yaron, at the Western Resources Conference, Boulder, Colorado; and "Economic Evaluation of Water Quality in Irrigation — Methodology and Some Empirical Findings," by Dan Yaron and A. Olian, at the Institute of Management Sciences, XX International Meeting, Tel Aviv. Another paper will appear in the *Journal of Horticultural Science*, and a final report was in preparation at the year's end.

Energy and Minerals

Solutions to the energy problems that confront the United States will require a complex set of achievements. The supply of energy from conventional sources needs to be expanded under acceptable cost and environmental conditions. In addition, new technologies will have to be devised to permit abundant resources to be substituted for those in short supply, again with due regard to costs and environmental circumstances. It is likely also that improved performance in the utilization of energy will be necessary, so as to reduce the continuous draft on new energy supplies. Finally, to move successfuly in these directions, improved understanding of the relationships between the supply of energy and the requirements of society, as well as improved analytical techniques for utilizing our knowledge of these relationships, will be sorely needed to guide policy action.

Research within the energy program touches upon these various facets. Energy supply is being analyzed in a major study that examines the broad range of options open to the United States for meeting its future needs; another study is specifically devoted to the research and development opportunities in new energy technologies. The prospects for achieving greater economies in energy use are being examined in a case study of opportunities for energy conservation in the New York metropolitan region. Improved understanding of the relationships between energy use and society is being sought in a study of social science research needs in the energy field, undertaken for the National Science Foundation. Methodological advances to permit better utilization of knowledge about the various aspects of energy were the objective of a seminar and publication in the area of energy modeling.

Publications during the year included the release early in 1973 of M. A. Adelman's widely noted study of *The World Petroleum Market*. The analysis presented in the book, and arguments derived from that analysis, played a prominent part in energy policy discussions during the year. Two publications in the newly established Working Paper series were also released: *Energy Mod-*

eling and *Patterns of Energy Consumption in the Greater New York City Area.*

At the end of the program year, Hans H. Landsberg was named to the post of program director. Sam H. Schurr, who has directed the energy and minerals program since its inception, has become director of Energy Systems, Environment and Conservation at the newly established Electric Power Research Institute. During the year Harry Perry was appointed as a consultant to the energy and minerals program.

PROGRAM OF ENERGY STUDIES

U.S. Energy Supply Options

A study of U.S. energy supply options, financed by a grant from the Ford Foundation as part of its Energy Policy Project, was in draft stage at the close of the program year. When the study was started a year ago, there was a consensus that the nation was moving toward a long-run position of heavy dependence upon imported oil and, to a lesser extent, natural gas. In view of the nation's large resource base of coal, oil shale, and nuclear fuels, and the probable existence of substantial underground resources of crude oil and natural gas, it was clear that, given enough time, public policy directed toward an enlarged domestic supply capability could be expected to meet with some degree of success. However, the trend toward contraction of domestic supplies of oil and gas had sufficient momentum that increased dependence upon foreign sources in the short term was considered inevitable.

In the year that has elapsed since the study was started, national concern about dependence on foreign sources has grown as a result of such factors as (a) the successful pressure from all oil exporting countries for substantial price increases; (b) the nationalization of foreign petroleum investments in some countries; and (c) the threat that many exporting countries, for both political and economic reasons, might not permit exports to grow enough to meet the import requirements of the United States and other industrial nations. Even the hopes that a high degree of self-sufficiency would be obtained for North America were dimmed by Canada's concern about the adequacy of energy resources to meet its own national needs.

Looking to 1980–85, preliminary results of the RFF research suggest that the outlook for expansion of domestic supplies of oil, natural gas, and coal is better than had been generally thought. On the other hand, the prospects for increased energy supplies through advanced technology within the next decade are not favorable, with the exception of oil shale, for which the amount of new technology required is actually not large. Nuclear energy will, of course, play an increasing role within this period but does not seem to lend itself well to much acceleration in growth. Toward

the end of the century new energy technologies such as solar, geothermal, breeder reactors, and fusion reactors may begin to play a significant role, but if the trend toward using imports is to be reversed, the domestic production emphasis during the next decade probably will need to be on oil, natural gas, and coal (used as coal).

In addition to Milton F. Searl of the regular staff, the study team includes Gregg Erickson, formerly staff economist on the Joint Pipeline Impact Committee of the Alaska State Legislature, Mike M. Maaghoul, a research assistant in chemical engineering at the University of Maryland, and Radford Schantz III. Other members of the group, who remain in residence at their respective universities, are Richard Gordon and John Tilton of the Department of Mineral Economics, Pennsylvania State University; Henry Steele of the Economics Department, University of Houston; and Helmut Frank of the Economics Department, University of Arizona.

An Overview of Energy R&D

In response to a request from the Committee on Interior and Insular Affairs of the U.S. Senate, RFF undertook the preparation of an overview report on energy research and development, for use in the National Fuels and Energy Policy Study being conducted by the Committee.

The main contribution of the report is in its description and analysis of alternative strategies for meeting the short-, medium-, and long-term energy needs of the United States. A very wide range of new energy technologies is covered. The alternatives span a spectrum ranging from immediate plant construction for producing synthetic supplies of liquids and gas, through an R&D program modeled on the wartime Manhattan Project for developing nuclear energy, and on to a "prudent" research commitment in which R&D proceeds in orderly sequence.

Harry Perry, who prepared the study, conducted interviews with numerous individuals and groups representing wide-ranging interests in energy R&D. The research arms of energy trade associations, research directors in the coal, oil, gas, and utility industries, private consultants, university professors, and government personnel engaged in R&D activities were all asked the same sets of questions with respect to five research areas, selected for their critical importance in any expanded R&D program.

The five R&D program areas selected for interview questions were: high-Btu gas from coal; liquid fuels from coal; liquid fuels from oil shale; low-sulfur fuels for generating electricity; and advanced power cycles for generating electricity.

By the end of the program year a draft report had been delivered to the Committee and was being considered for publication as a Committee Print.

Energy Consumption in the New York Metropolitan Region

Research progressed during the year on a study designed to evaluate energy consumption trends and energy conservation opportunities in the New York City metropolitan region. The study, which is being conducted jointly by RFF and the Regional Plan Association of New York, has been financed through a special grant from the Ford Foundation. The key question posed is how levels and rates of growth in the region's energy consumption might be dampened by purposeful conservation measures in different user sectors.

Analysis of this issue requires an underlying data base describing the region's historic pattern of energy utilization and related economic and demographic variables. During the year, two interim statistical reports presenting such information, as well as selected preliminary projections, were completed. They are probably the first effort to depict the New York City area's aggregate fuel and power utilization, by consuming sector, energy form, and primary energy source.

The first of the two interim statistical reports — *Patterns of Energy Consumption in the Greater New York City Area* (RFF Working Paper EN-2, July 1973) — presents data on energy and related aspects for the Greater New York City area, defined as the five boroughs of New York City, and the counties of Westchester, Suffolk, and Nassau. A broader geographic picture is contained in the draft of a second interim report, which will comprise a forthcoming edition of the Regional Plan Association's periodic publication, *Regional Plan News*. Scheduled to appear as an RPA publication soon after the close of the 1972–73 program year, it features data and comments on the thirty-one county region constituting the Regional Plan Association study area.

Among other findings, the statistical report on patterns of energy use in the Greater New York City area reveals that per capita energy consumption was 15 percent below the New York State per capita level and 43 percent below the U.S. average. A similar relationship holds for electric power alone. Relatively low per capita energy and electricity usage prevails in spite of the area's higher-than-average per capita income status; per dollar of 1970 money income, energy consumption in the area was less than one-half the national figure. Among the probable explanations for this pattern of energy usage are the absence of energy-intensive heavy industry and a relatively widespread network of public transport, with more efficient energy usage than private passenger cars.

Obviously, New York's energy use — while low by national standards — does not preclude significant energy savings in the years ahead. Nor does the comparatively low per capita use make any less real the fuel and power supply problems being experienced by the region. From an environmental standpoint, it is worth noting that, in a dense urban agglomeration like the Greater

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New York City area, even a relatively low per capita utilization of energy signifies a vastly greater degree of energy consumption per square mile of area than for the country in general.

The final report in this series will be an interpretive study which evaluates the outlook for energy conservation in the context of the region's unfolding economic and demographic development. The report will be concerned with the potential quantitative significance of energy-conserving practices in such applications as space heating and transportation, as well as with measures designed to bring such developments about.

The participants in the RFF portion of the study are Joel Darmstadter and Elizabeth Vogely.

Energy Modeling

A beneficial side effect of the rapidly growing concern with the problems of energy is the impetus provided for quantitative analysis. The quantity of work in progress clearly suggests the need for achieving communication among members of the newly emerging community of scholars engaged in this field. To this end a seminar was held in Washington on January 25–26, 1973, attended by an invited group of eighty.

The papers presented at the seminar were quickly published. *Energy Modeling* (RFF Working Paper EN-1) was available for distribution in March. The volume includes a set of comments on the papers prepared by Milton Searl, who planned the meetings and edited the papers for publication.

The sixteen papers in the volume fall within the following broad subjects: Use of Input-Output and Econometric Techniques for Energy System Modeling; Use of Linear Programming in Energy Models; Econometric Models of Individual Sectors; Current Government and Industry Models; Continental Energy Models; Historical Perspective on Demand Forecasts. The authors are: William A. Reardon, Battelle Pacific Northwest Laboratories; Clopper Almon, University of Maryland; Philip K. Verleger, Jr., Data Resources, Inc.; Kenneth C. Hoffman, Brookhaven National Laboratory; D. E. Deonigi and R. L. Engel, Battelle Pacific Northwest Laboratories; James M. Griffin, University of Houston; Edward W. Erickson, North Carolina State University; Robert M. Spann, Virginia Polytechnic Institute; Robert Ciliano, Decision Sciences Corporation; Duane Chapman and Timothy Mount, Cornell University; Timothy Tyrrell, Oak Ridge National Laboratory; W. E. Mooz, The Rand Corporation; James A. West, U.S. Department of the Interior; Andrew Avramides, National Petroleum Council Staff; James S. Cross, Sun Oil Company; Dilip R. Limaye and John R. Sharko, Decision Sciences Corporation; J. G. Debannė, University of Ottawa; Leonard Waverman, University of Toronto; and Hans H. Landsberg, Resources for the Future.

Social Science Research in Energy

At the request of the RANN program of the National Science Foundation, a study to identify social science research needs in the energy field was undertaken. The study follows up on two earlier RFF surveys dealing with energy research needs: *U.S. Energy Policies: An Agenda for Research* (1968) and *Energy Research Needs* (1971).

Begun in 1973, with Sam H. Schurr and Hans H. Landsberg as co-principal investigators, the study relies heavily on outside contributions and collaboration. Recognized scholars in major fields were invited to prepare papers identifying research needs as follows: data base — Kenneth C. Hoffman and H. G. Jones; modeling and forecasting — Alan S. Manne; the characteristics of the energy industries — Stephen L. McDonald (incentives), Almarin Phillips (rate regulation), Thomas D. Duchesneau (structure); capital and financing — Clark A. Hawkins; conservation in use — Joel Darmstadter and Eric Hirst; environmental trade-offs — Marc Roberts; research and development strategy — Burton H. Klein; U.S. energy in the world setting — James W. McKie; policy formation, implementation, and institutions — Edward J. Mitchell, Robert M. Lawrence, and Gerald Garvey.

Two basic subcontracts were made, one with the Denver Research Institute, which made available John J. Schanz, Jr., and other personnel for the purpose of organizing the preparation of papers and coordinating the workshops, and the Environmental Law Institute, which, through Grant Thompson, undertook to draw from environmentalists both original contributions and reactions to the commissioned papers.

A report was scheduled for submission to the National Science Foundation in the fall of 1973. It will include the commissioned papers, a summary of an environmentalist's workshop, and a summary report that will constitute the core of the study. This last was prepared by the RFF staff, augmented by John Schanz and his associates at the Denver Research Institute, with a panel of special consultants consisting of Almarin Phillips, Joseph Bell, Gerald Garvey, and Thomas Stoel. The entire study was financed by the National Science Foundation.

Economics of Energy R&D

In further response to the NSF request, and also funded by that Foundation, is a companion report commissioned late in the program year on *Energy R&D — The Contribution of Economics*. John Tilton, Department of Mineral Economics, Pennsylvania State University, has been asked to prepare a basic paper by the end of 1973 that will serve as the focus of an early 1974 symposium to be attended by R&D experts in economics, political science, technology, and other pertinent fields. The study will address itself to such questions as the search for criteria affording an

optimal allocation of resources in energy R&D; the role of the market, including market failure, in bringing about resource allocations in this area; the case for government intervention; and the incidence of R&D costs. The study will deal also with a review of energy R&D policy as it is found in the United States today. A report integrating the results of the symposium with his paper will be prepared by Tilton.

U.S. and Canadian Trade in Energy

Work proceeded on the RFF-sponsored study of the prospects and problems of U.S.–Canadian energy trade, being conducted jointly by scholars at the University of Denver and the University of British Columbia. A two and one-half day seminar was held in Vancouver in October 1972 for the purpose of discussing draft papers on the evolving energy situation in Canada and the United States, and the emerging policy issues as perceived in the two countries. The seminar was attended by an invited group consisting of Canadian and U.S. government and industry officials and energy researchers.

The seminar discussions produced major new insights on questions that are critical to the growth of energy trade between the two countries. In particular, the strength of the opposition within Canada — for a variety of economic and political reasons — to greatly enlarged oil and gas exports to the United States became clear. Means for achieving a reconciliation of Canadian and U.S. interests were discussed at length. On the basis of the facts and policy positions that were brought forward in the seminar discussions, the participants in the study, Paul G. Bradley of the University of British Columbia, John Schanz of the University of Denver, and Helmut Frank of the University of Arizona, are preparing revised versions of the papers originally developed for the Vancouver meetings.

Outer Continental Shelf Drilling

One of the potentially rich geographic areas from which additional oil and gas might be obtained is the outer continental shelf. While drilling and production have gone a considerable way along the Pacific Coast and in the Gulf of Mexico, both the Atlantic Coast and the Arctic shelf remain untouched so far. Prominent among unresolved issues in this context are the likely environmental consequences that exploratory and exploitative drilling might have in these two locations.

Following a directive from the President to evaluate environmental impact in the light of known and feasible technology, the Council on Environmental Quality in the summer of 1973 commissioned a series of studies and arranged public hearings designed to establish benchmark data and lay the basis for policy decisions regarding the future course of resource development in these areas.

In mid-September 1973, RFF agreed to be responsible for assembling several small groups of experts at a two-day meeting in an effort to identify points of disagreement regarding the state of the arts and knowledge in various phases of offshore drilling, the grounds for controversy, the means of resolving them, and desirable directions of research. A grant was made by CEQ to RFF for the purpose, and a report is scheduled to be made to CEQ following the meeting. Principal research work will be in the hands of Harry Perry.

International Oil

The World Petroleum Market by M. A. Adelman was published early in 1973. The findings and arguments developed in this study have been widely noted in the general news media as well as in the specialized energy press. The research leading to this book was supported by grants to the Massachusetts Institute of Technology, where Adelman is professor of economics.

Saudi Arabian Income from Oil Exports

There is increasing worldwide concern about the impact of rising petroleum imports on the balance of payments of the United States and other countries, and the effects of rapidly growing oil earnings in Middle Eastern exporting countries on the international monetary and financial system.

Because of its enormous oil potential — far greater than that of any other exporting country — a major proportion of these imports will originate with Saudi Arabia. A study was begun during the year to prepare some preliminary estimates of the magnitude of export flows, oil earnings, budgetary impacts, and expenditure patterns in Saudi Arabia in the years ahead. The research is being performed by Donald A. Wells of the Department of Economics, University of Arizona. Wells had earlier served as economic consultant to the Ford Foundation in Saudi Arabia, and has published studies on the Saudi Arabian oil industry.

U.S. Oil Import Policy

In the United States, the declining trend in crude oil and natural gas reserves has brought into sharp focus the prospect of a far greater comparative reliance on imported supplies in the future. At the same time, the problems that would arise from heavy reliance on importation from the major exporting countries that are members of the Organization of Petroleum Exporting Countries are seen as being greater than in the past, owing to the hard negotiating position that these countries have recently adopted. Not only have the economic terms on which imports are obtainable grown more severe, but bargaining for economic objectives has involved use of the threat of an embargo on oil shipments as

a commercial weapon, in addition to its long-standing use as a political weapon. These developments have given rise to new concerns in regard to security of imported supplies.

In view of the numerous economic, political, and international complexities which bear upon this subject, RFF has revived this project, which had been started a number of years ago, but terminated in 1970 with the deaths of the principal investigators, Wallace F. Lovejoy and Paul T. Homan of Southern Methodist University. A new RFF grant to The University of Southern Illinois at Carbondale will be used by Milton Russell and Douglas Bohi to carry forward the work begun earlier.

NONFUEL MINERAL STUDIES

World Copper Mining Industry

Work on a study of the world copper mining industry is being continued by Raymond F. Mikesell, financed through a 1971 grant to the University of Oregon.

In 1972, free world copper mining capacity consisted of 2.9 million metric tons in the developing countries and another 1.1 million in Canada, Australia, and South Africa. The United States, Europe, and Japan accounted for another 2.9 million metric tons, but these areas were also the major importers. The vast bulk of world copper exports are accounted for by a handful of less developed countries (LDCs) and most of the increased capacity that is expected over the next decade will be located in the LDCs. The free world demand is projected to rise at an annual rate of about 4.3 percent over the next twenty-five years. To finance the projected increase in free world copper mining capacity over the period 1972–77 will require an investment of $1 to $1.5 billion a year, most of it in the developing countries.

Nearly all of the copper mining capacity outside of the United States, Europe, and Japan was established by foreign investment from the United States and Europe, and more recently from Japan. However, there has been a rapid change in the pattern of ownership and control over the past decade. In 1960, producer country governments held an interest in only 2.5 percent of free world copper producing capacity, but by 1971 these governments had an equity interest in production facilities representing 43 percent of free world capacity. Moreover, the trend toward nationalization in copper mining is likely to continue. Even in countries like Canada and Australia, there is strong movement to limit future foreign investment in the mining industry. A major objective of the study, therefore, is to assess the impact of these changes in ownership and control on the future supply of copper.

In spite of the nationalization movement, both at the present time and for a number of years to come, the large international copper companies will play a major, if not a determining role, in

the expansion of copper producing capacity in the developing countries. Therefore, another important aspect of the study concerns the motivations and the investment practices of the international copper companies in the negotiation and renegotiation of mining contracts. Mikesell has already prepared such studies for Zambia, Zaire, Bougainville (Papua-New Guinea), and Peru, and has collected materials for a fairly complete history of the Chilean negotiations under the Frei administration and of the experience of the Chilean copper industry under the Allende regime. Work is in progress on the experience of Cerro de Pasco in Peru and on the efforts of the Peruvian state mining agency, Minero Peru, to carry out a number of copper projects.

Metal Trade Patterns

Metals loom large in the trade among nations. To a considerable extent, industrialized countries, which are major users, must depend upon exports originating in countries specializing in production of particular raw materials. Many of the exporting countries are in the less developed world, and trade in these commodities is complicated by serious economic and political problems. What accounts for the actual patterns of trade and for changes in these patterns over time? What is the relative importance of such factors as comparative resource endowment, the nature of technological processes, transportation costs, political relationships, the operations of multinational corporations?

Pennsylvania State University received a grant of $36,814 from RFF to support research on this subject by John Tilton of the Department of Mineral Economics, to be started early in 1974. Tilton will attempt in his study to unravel the changing importance of the various elements involved in order to explain what has happened in the past and to provide a basis for estimating what may happen to trading patterns in the future. The susceptibility of trading patterns to changes in underlying resource, economic, and technological factors, as well as to changes in government and business policies, will be assessed along both technical and empirical lines.

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Regional and Urban Studies

During the year, RFF's program in metropolitan governance was recast to tap the research findings of young scholars working in the field; a book titled *Cities, Regions and Public Policy* (edited by Gordon Cameron and Lowdon Wingo for Oliver and Boyd, Edinburgh) resulted from the joint U.S.–British Glasgow Conference on Urban Development Strategy; work on information resources by Edgar Dunn culminated in a volume accepted for publication by Wiley Interscience; a grant from the National Science Foundation was received for work on structural changes in the regional and urban economy from 1940 to 1970; and work continued on the issues concerned with the quality of life in relation to urban scale. Lowdon Wingo, who has headed the regional and urban studies program for the last five years, resigned to become chairman of the City Planning Department, University of Pennsylvania. He was succeeded by Edwin T. Haefele.

METROPOLITAN GOVERNANCE

Further work on metropolitan governance is being undertaken in cooperation with the Academy for Contemporary Problems. The Academy is interested in the practical problems faced by local government officials in metropolitan areas and, with the help of RFF's reconstituted Metropolitan Governance Research Committee, will bring the results of research findings to the attention of these officials. At the same time, the concerns of the officials can be effectively transmitted to researchers, helping the latter to choose relevant problems for study. Serving on the RFF Committee are:

William Alonso, Professor, Institute of Urban and Regional Development, University of California (Berkeley)

Sterling Brubaker, Senior Research Associate, Resources for the Future

Daniel Wm. Fessler, Professor, School of Law, University of California (Davis)

Joseph L. Fisher, President, Resources for the Future
Bernard J. Frieden, Director, MIT–Harvard Joint Center for Urban Studies
Edwin T. Haefele, Director, Regional and Urban Studies, Resources for the Future
Capt. Erick Hanushek, Department of Economics, U.S. Air Force Academy
John E. Jackson, Professor, Department of Government, Harvard University (Executive Secretary of the Committee)
Ted Kolderie, Executive Director, Citizens League of Minneapolis–St. Paul
Martin McGuire, Professor, Department of Economics, University of Maryland
Mancur Olson, Professor, Department of Economics, University of Maryland
Wallace Oates, Professor, Department of Economics, Princeton University
George Peterson, Senior Research Staff, The Urban Institute
John Ries, Professor, Institute for Governmental Relations, University of California (Los Angeles)
Ralph Widner, Director, Academy for Contemporary Problems
Lowdon Wingo, Jr., Chairman, Department of City and Regional Planning, University of Pennsylvania

Two conferences are being planned for the new committee. The first, held in October 1973, focused on how local changes in population and economic activity affect the demands for locally provided public services, and the reciprocal effect of the public services provided on migration patterns. The second, to be held in the spring of 1974, will be concerned with sources of revenue for local governments and the relationship of these sources to public output.

The fourth volume in the series of studies on the Governance of Metropolitan Regions, entitled *Reform as Reorganization*, was in press at the end of the year.

INFORMATION RESOURCES

During the year, Edgar Dunn completed a study devoted to specifying the nature of our generic problems with social information processing and how these relate to various proposals for statistical reform currently being voiced.

Dunn has been identified for some time with these issues — as an official of the Department of Commerce, as a consultant to the Office of Management and Budget, as a member of the advisory board of the National Academy of Science's study of computer data banks, and as the author of a number of papers. In his view, the major statistical reform proposals of the 1960s — social indicators, social accounting, microdata, data banking, program evalua-

tion, statistical professionalism — have ignored fundamental issues of concept and system design. These proposals emerged from concepts that fail to show how each may be related in a systematic way to the others. More important, the proposed reforms are incapable of handling the overarching problems of information processing that generate the difficulties.

To provide a better conceptual base for dealing with these issues, Dunn sketches a theory of social information processing, which he uses both to evaluate the reform proposals and to identify requirements for the development of information resources for the future. He also examines the controversial issue of personal privacy in the broad context of the relationships between human freedom and the use of information in society.

Dunn's book, *Social Information Processing and Statistical Systems — Change and Reform*, is in process of publication by Wiley Interscience.

STRUCTURAL CHANGE IN THE REGIONAL AND URBAN ECONOMY

In June, RFF received a grant of $104,500 from the National Science Foundation, making it possible to complete a comprehensive statistical analysis of the changing structure of the regional and urban subeconomies of the United States between 1940 and 1970. This project was begun by Edgar Dunn in the mid-sixties, but was held in abeyance until a special tabulation based upon the 1970 Census could be obtained.

Analysis of the data will be guided by a number of questions: Does the structure and history of a region, when compared with that of other regions, or with the same region differently depicted, suggest something about its developmental options? Can we extract examples of natural growth poles from this historical experience and identify similarities and differences between them? How do the historical patterns illuminate our current policy interests in population growth and distribution? How are changes in structure related to the size of nodal urban regions and their internal settlement patterns? What are the observable regional differences in the dynamic patterns or sequences of growth? Do they suggest the forces that generate them? Can we identify some of the differences between national and regional sources of growth?

A New Research Approach

The basic strategy differs in several respects from conventional regional and urban research. It will emphasize the use of a set of techniques to represent patterns formed by changes in the functional structure of a variety of regional and urban entities. More commonly the work in this field has dealt with forming economic–demographic projections, testing fairly simple relational hypo-

theses, or parameterizing simple planning models. Even where pattern representations have been attempted, they were typically restricted to cross sections of functional structures at a point in time. This project focuses upon the structure and change of whole sets of regional and urban complexes within the larger environmental complex we know as the United States. In contrast to the formal testing of simple relational hypotheses, it seeks to examine whether systematic developmental hypotheses are generally consistent with the historical record.

Sources and Methods

A variety of data sources will be employed, but the study will lean most heavily upon income and employment data by industry for all of the counties and Business Economic Areas in the United States. Strong reliance will be placed on applications of a revised version of the familiar shift-share technique developed by Dunn in the mid-fifties in connection with an earlier RFF study.

A major analytical and descriptive volume is planned to present the principal results of the study.

A New Service Utility

The requirements for collecting and analyzing data for this study include: the development of a data base of historically consistent descriptors; a unique set of computer software for carrying out a somewhat novel research strategy; and an economical and flexible computer routine for producing data maps for the United States (depicting both county and economic area data). Because these research resources will have wider application for future work in related areas, arrangements have been made with the Laboratory for Computer Graphics at Harvard University and with the Bureau of Economic Analysis of the Department of Commerce to develop and maintain them in serviceable use after the completion of this project.

QUALITY OF LIFE AND URBAN SCALE

Irving Hoch continued his investigations into the quality of life and urban scale, the latter defined as embracing urban population size and density. Additional evidence was developed on the basic thesis that there is a net decline in the quality of life with increasing scale, but that this tends to be compensated for by increasing money wages for the same work. This is not to say that what exists is the best of all possible worlds; there is much scope for institutional improvement. Among the improvements suggested are better pricing and, particularly, the imposition of effluent charges for the use of common property resources in the urban environment.

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During the program year, Hoch developed information on density relationships, on cost of living related to scale, and on nonmarket costs and benefits — primarily in the area of urban crime. A strong relation holds between the scale factors, density increasing with urban size. Within urban areas, density declines from a peak at the city center; over time, this relation has flattened out, reflecting suburban sprawl and increased automobile ownership. Recent Census data show that this trend in the spread of cities has continued over the last decade, but there is some evidence that it is approaching a limit. In western cities, particularly, there are indications that automobile ownership is approaching saturation, and that urban density is beginning to increase. Further, there is evidence that air and noise pollution helped to increase urban spread, and, hence, that environmental cleanup may also lead to some reversal of the dispersion.

Some observers, unhappy with the negative consequences of large cities, have called for a penalty tax on inhabitants that increases with urban size. But if it is true, as indicated above, that money wages increase with urban size, then the progressive income tax fulfills this objective now. Comparing budgets for an urban area of 100,000 persons with one of 10 million, the cost of living, on average, is about 10 percent higher in the latter than the former, with about 1 percent of the 10 percent difference accounted for by the progressive income tax. Of course, this tax differential varies by income class; it amounts to about one-half of 1 percent for low-income, 1 percent for middle-income, and 2 percent for upper-income families.

Although crime rates increase with urban size, the relationship has typically been overstated, since much of the increase reflects changes that occur in the demographic and ethnic composition of the populace as urban size increases, rather than the change in size, per se. Using multiple regression analysis, each of seven major crimes was related to a large number of explanatory measures, including urban scale measures. The analysis disclosed that: increased unemployment was associated with increased property crimes; higher summer temperatures increased crimes of violence; an increase in the proportions of both the young and the old reduced crime rates. An increase in crowded housing, and in the percentage of male primary individuals (persons living alone or with nonrelatives), increased crime rates. Rates also tended to be higher in the South and, to a lesser degree, in the West. Ethnic factors were often important, with evidence that Japanese and children of the foreign born had lower crime rates than average, while American Indians, blacks, all other nonwhites, and the foreign born had rates above average. The American Indian rates appeared to be the highest of any group, and northern black rates appeared considerably higher than those of southern blacks. Growth in urban population was usually associated with increased crime, and there was some remaining positive effect for popula-

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1970 CRIME RATES BY URBAN POPULATION CLASS, ACTUAL AND AS A FUNCTION OF URBAN SCALE (percentage of sample average)

Population class (thousands)	Homicide	Rape	Robbery	Assault	Burglary	Larceny	Auto Theft
Urban crime index (sample average = 100):							
0 - <250	84.85	73.92	61.62	84.58	80.10	88.74	61.39
250 - <500	94.38	88.80	67.30	95.00	93.79	91.16	74.95
500 - <1,000	100.04	96.19	90.78	96.11	102.24	103.92	120.02
1,000 - <2,500	117.60	133.58	151.65	111.91	116.44	115.10	128.41
2,500 - <9,000	132.61	154.35	251.52	134.17	125.59	114.63	170.85
≥9,000 (NYC)	137.87	105.76	470.35	177.84	156.36	156.57	199.63
Index as function of scale effects only:							
0 - <250	96.16	91.83	94.47	100.70	94.19	102.70	73.06
250 - <500	96.11	96.16	95.74	95.78	97.30	97.85	86.32
500 - <1,000	98.73	98.19	103.61	99.39	104.96	107.69	117.00
1,000 - <2,500	109.69	121.24	102.42	103.74	102.20	98.05	119.03
2,500 - <9,000	107.48	66.00	116.59	107.10	102.54	80.15	119.14
≥9,000 (NYC)	98.04	64.83	136.75	133.96	135.68	117.83	107.86

If age, ethnic group, employment rate, geographic area, and other factors that might influence crime are held constant, the effect of urban scale alone (as measured by population size) can be observed. The figures are based on average crime rates in a sample of 137 urban areas. The tabulation results from an on-going NIE study of the quality of life and urban scale.

tion size, even after all other variables were taken into account. But, somewhat surprisingly, increased population density was associated with a decrease in crime, and this largely offset the effect of increases in size.

For the sample of 137 urban areas that was employed, we can compare actual crime rates, shown as percentages of the average level, to calculated crime rates assuming that all factors, except urban scale factors, are the same between places. In doing so, we ask: If percentages of old, young, ethnic groups, and so on, were the same between places, but only size and density varied, what levels of crime would be observed as size of place increased? The results indicate a very substantial reduction in crime rates when the other factors have been taken into account. (In the case of robbery, the results shown for "scale effects," only abstract from an interaction that occurs between the black population and urban size, which probably reflects the problem of narcotics addiction; with this interaction included, a narrowing of crime differentials still occurs, but is not as pronounced.)

A detailed discussion of the crime study appears in a paper scheduled for publication in the *Journal of Urban Economics*.

HUD Study

Toward the close of the program year, the Department of Housing and Urban Development requested that RFF review what was known about the major relationships between natural resources and environmental quality, on the one hand, and regional and urban development patterns, on the other. Because many aspects of the problem were related to Hoch's ongoing research efforts, he assumed primary responsibility for the report.

A CULTURAL ANALYSIS OF AMERICAN BELIEFS ABOUT REAL PROPERTY

Beliefs about real property are defined as those ideas people have about such topics as: the sources of property decline, what land uses are antagonistic and complementary, how renters and owners differ, what risk consists of and who bears it, what comprises appreciation and depreciation of values, and how one piece of property affects another. Constance Perin has begun a study of the belief systems of the main factors in the land development process in metropolitan areas. As a cultural analysis the study is intended to consider the meanings and significance of the questions listed above for those occupationally involved in them. It is not a psychological study of motives, nor an analysis in the mode of "interest group" theory. The study views the chaos and the problems of land use in metropolitan areas as a political and social process in which these cultural premises play an important role. Ultimately the research should be useful in constructing policies for ameliorating the disutilities and conflicts that now characterize much metropolitan development. Interviews are being held with mortgage bankers, assessors, appraisers, HUD officials, realtors, developers, and legislators in two large metropolitan areas in different regions of the country.

The research has these major practical and theoretical objectives: to create a data archive of contemporary American beliefs about real property (also to be made available to other analysts in, for example, history, law, and political science); to define the cultural meanings of land and property resources and the unstated assumptions or "social rules" used in allocating them among groups; and to weigh the relative strength of national, regional, and local ideals, beliefs, and norms in the operation of the private property system.

CONGRESSIONAL SEMINAR

With special support from the Ford Foundation, RFF and the National Planning Association conducted a seminar on national urban growth policy for selected members of Congress and their staffs. The seminar was suggested by Senator John Sparkman, Chairman of the Subcommittee on Housing and Urban Affairs. Eight sessions were held, each led by an outstanding scholar:

Ralph Widner	National Urban Growth Policy: Elements and Interrelations
C. E. Bishop	Rural Development
Bennett Harrison	The Metropolitan Problem
William Alonso	The National Settlement Pattern
Julius Margolis	Public Finance
Peter Morrison	Internal Migration
Harvey Garn	The Location of Employment
Ben Chinitz	National Urban Growth Processes: Implications for Policy

The sessions were designed to bring legislators and their staffs together with key members of the social science community to exchange viewpoints and knowledge on critical issues of national growth policy. The purpose was to increase the flow of information about the social and economic implications of emerging national growth strategies.

NEW GRANT

At the close of the year, a grant of $300,000 from the Edna McConnell Clark Foundation was made to RFF to study problems of social choice and institutional design. Edwin T. Haefele will direct the program.

Appraisals and Special Projects

Several projects conducted or sponsored by Resources for the Future are administered separately from the major categories of research dealt with elsewhere in this report. Some are an outgrowth of RFF's 1963 appraisal of resource adequacy in the United States, and deal with situations where sufficiency of resource supply may be in question or where technology has opened up new possibilities in the use of a resource. Some other projects relate to marine resource issues, to RFF's new policy studies, and to the continuing studies of population–environment relationships. A few are extensions of RFF's educational function — an integral part of each of its research programs.

RESOURCE APPRAISALS

As part of RFF's contribution to the work of the Commission on Population Growth and the American Future, a revision and updating of the material published in 1963 as *Resources in America's Future* was undertaken in 1972. Some of the results of the initial effort were published in Volume III of the Commission Research Papers under the title "Adequacy of Nonfuel Minerals and Forest Resources." Written by Leonard L. Fischman and Hans H. Landsberg, the study rested on demand projections geared to 1970 consumption data and, in the style of the original study, was projected on the basis of reasonably visible developments — social, technological, and others.

Because of the limited time allowed by the Commission schedule, no original work was undertaken in the areas of reserves and resources and non-U.S. demand; instead, recourse was had to data then available from the Bureau of Mines.

An article contributed by Hans Landsberg to RFF's *Energy Modeling* (see Energy and Minerals section) was also derived from the preliminary revision. In this analysis, 1970 projections made ten years earlier are compared with the actual performance

of the U.S. economy in the energy field, at least as far as demand for various forms of energy is concerned.

In August 1973 Leonard L. Fischman rejoined the RFF staff on a part-time basis to participate in the resource appraisals project. The round of revisions now under way will test the model developed previously for inconsistencies and weak spots, and will validate reasoning underlying the new projections.

The Economics of Materials Adequacy and Substitution

Taking a very long view of resource adequacy, Frederick J. Wells perfected his study of phosphate availability, which has been reviewed by experts on both the supply and the demand side. Because of the irreplaceability of phosphates as a plant nutrient, and the rising need for food under population and income trends that will not soon level out for the world as a whole, the outlook for phosphates has obvious importance.

In his study, Wells discusses not only the resource aspect, taking into account phosphate sources not now exploited, and the speculative cost associated with these sources, but also the derivation of demand projections, based on nutrient-yield relationships. He concludes that phosphate inadequacy is not a problem that need concern us for a long time to come. At the same time, he clearly sets out the rising costs that will be encountered as poorer sources come into play.

Stemming from the same conviction that a study of the outer boundaries of resource availability is an instructive way of looking at adequacy, a research project was developed that attempts to deal with the ways in which a hypothesized "resource-poor" future society would deal with scarcity or total absence of specified substances. By way of a pilot project, a research contract was made with S. Victor Radcliffe, head of the Division of Metallurgy and Materials Science at Case Western Reserve University, to identify in detail the functions of all materials contained in an automobile, and to assess the consequences in terms of costs, performance, etc., that substitutions of materials stipulated as scarce (copper, nickel, zinc, lead, etc.) by materials stipulated as widely abundant (aluminum, magnesium, iron, silicon, etc.) would entail.

The study, which was well launched by the end of the program year, should reveal the extent to which evaluation of responses to materials scarcity is a useful alternative approach to more conventional investigations in which selection of a given time horizon plays a crucial role.

SPECIAL PROJECTS

International Studies of Fisheries Arrangements

The problems of the management and allocation of the sea's wealth in fisheries are among the most difficult that will face the

Third United Nations Conference on the Law of the Sea. In recognition of this, RFF, with the help of a supplemental grant from the Ford Foundation, initiated last year a program of international studies of fisheries arrangements. The program has two parts: The first is the preparation of a series of working papers on alternative arrangements for particular fishery regions and situations. The second involves the presentation and distribution of the working papers to those persons throughout the world who will have an influence on the decisions at the UN Conference.

During the year, two of the working papers were printed: *Alternative Arrangements for Marine Fisheries: An Overview*, by Francis T. Christy, Jr., director of the program, and *North Pacific Fisheries Management*, by Hiroshi Kasahara and William T. Burke. Kasahara, currently program coordinator of the UN Food and Agriculture Organization's Fisheries Department, was a professor of fisheries at the College of Fisheries, University of Washington, when the study was being prepared. Burke is a law professor at the University of Washington. His research was done under an earlier grant to that university.

"Alternatives for the Management of West African Marine Fisheries," by James A. Crutchfield and Rowena Lawson, is the third working paper in the series and is currently being edited. Crutchfield, coauthor of an earlier RFF book, *The Pacific Salmon Fisheries*, is a professor of economics at the University of Washington. Lawson is currently senior lecturer in the Department of Economics at the University of Hull, England. Her work was supported by a grant made last year to York University. The fourth study, "Alternative Organizational Arrangements for Global Management of Fisheries," is in final review stage. It was written by Edward Miles of the Graduate School of International Studies, University of Denver. Also in review are "Fisheries of the Indian Ocean: Issues of International Management and the Law of the Sea," by Arlon Tussing, professor of economics at the University of Alaska, and Robin Ann Hiebert; and "Alternative Management Arrangements for World Tuna Fisheries," by Saul Saila and Virgil Norton of the University of Rhode Island. During the year, RFF made grants of $16,000 to the University of Alaska for support of the former study, and $9,883 to the University of Rhode Island for the latter. One or two studies, including a final review, remain to be written. In addition, the progam provided a stipend of $1,000 to Terese Sulikowski for the translation into English of a Soviet book, *Oceans, Technology and Law*, edited by M. I. Lazarev and L. V. Speranskaya. The book, published in Russian in 1972, contains many important articles on the law of the sea by such experts as P. D. Barabolya, S. N. Smirnov, A. L. Kolodkin, and A. A. Volkov.

As a whole, the working papers for the program comprise a fairly comprehensive discussion of the wide variety of fishery problems throughout the world. The problems are quite disparate

in the different regions and are likely to be affected in quite different ways by the decisions that may be made at the UN Conference. In the North Pacific, for example, there are only a handful of nations directly concerned, most of which are developed nations. In this region, there has been a long history of agreements and conventions between the interested states. On the other hand, the fisheries off the West African coast are of interest not only to numerous coastal states but also to about a dozen distant-water countries, and there has been little history of international agreement.

In the Indian Ocean, opportunities for expansion of fisheries appear to be greater than elsewhere in the world, while, at the same time, the potential for international conflicts appears to be less because of the proximity of most resources to land. Tuna is a special problem, and should be considered a global resource, both because of the widely migratory patterns of the species and because of the worldwide mobility of most of the tuna vessels.

In illustrating the disparity in fishery situations and in providing discussion of the implications of alternative measures, the RFF working papers are designed to help the delegates at the UN Conference arrive at acceptable and desirable decisions on international regimes. In attempting to achieve this design, the materials produced by the program have been presented at various international forums, where participants include those who will have some influence on the decisons of the Law of the Sea Conference. Brief, preliminary presentations were made by Christy at a meeting of the Asian-African Legal Consultative Committee in Delhi and at the fourth annual *Pacem in Maribus* Conference in Malta. The most important presentation was made during the summer meetings of the UN Sea-Bed Committee in Geneva. There, in cooperation with the Law of the Sea Institute and with the aid of the World Federation of United Nations Associations, RFF held a series of luncheon and dinner seminars for the UN delegates. At these seminars, the authors of the various working papers discussed their findings before small groups of selected delegates. Representatives of more than forty countries participated in these discussions, and copies of all six papers, either in final or preliminary form, were distributed to all delegations.

Policy Studies

The RFF policy studies program initiated last year resulted in one book-length publication; another study is in manuscript form, and two more are under way. Additional work bearing on policy issues is carried out in other RFF programs.

A review of legal issues raised by the National Environmental Policy Act, by Frederick Anderson with the assistance of Robert Daniels, was published under the title *NEPA in the Courts — A Legal Analysis of the National Environmental Policy Act*. NEPA

is the broadest legislative statement of the nation's recent commitment to protect the quality of its environment. The requirement for detailed impact statements on all federal actions that significantly affect the quality of the environment has had a profound effect on the decision-making process of federal agencies. However, this result has come about not merely through the normal bureaucratic implementation of the law; equally important has been the spur of citizen groups who have turned to the courts to give substance to the act. The result has been a rapidly growing body of case law that has defined the meaning of the act in a way that could hardly have been foreseen by its authors.

The Anderson study has grouped the case materials around a number of issues raised in the course of judicial interpretation — such matters as standing to sue, which agencies are covered and which of their actions require a statement, the transitional problems of applying the law to activities already under way, and what constitutes an adequate statement and proper procedures. For each topic the trend in the law has been traced. In some cases the book goes beyond this to comment on the decisions and to suggest future directions. Anderson concludes that, while NEPA has not yet had much effect in bringing about a better environment, the procedures for proper agency review of environmental impact are in place. He believes that subsequent court interpretations may expand NEPA so as to permit a more rational approach to broader policy issues at an earlier stage of their development.

An overview of resource and environmental policy issues undertaken by Sterling Brubaker was in manuscript form at the end of the program year. Too often the various resource and environmental problems are considered in isolation, with those concerned about environment taking little thought for the resource implications of their proposals and vice versa. Meanwhile we may work at cross-purposes even within some of the larger policy areas; for example, when pollution controls applied to one receiving medium force environmental consequences on another that already is in trouble. The basic approach followed in this review has been to identify objectives broadly supported by the public and to try to discern how a longer-range sense of direction, and planning of broader scope, can help to reduce conflict among objectives — particularly the conflict often seen between the objectives of income growth and environmental quality. Possible strategies for land use, energy, minerals, pollution abatement, and the international aspects of resource and environmental policies all have been treated within this framework. While the long-range view is preserved, an attempt is made to show how many current policy issues must fit into it. The study draws freely on the fund of RFF research work done in recent years in all of the areas of our interest.

More detailed policy analysis is represented in two other studies under way. One is an examination of recent innovations in land

use planning. This is being undertaken by Robert Healy, formerly of the Urban Institute, who joined RFF during the program year. For decades, land use controls in the United States have been exercised at the local level, or not at all. Now, under the pressure of population growth, urban expansion, and environmental concern, we are moving toward broader jurisdiction over land use matters. Pending federal legislation is being preceded in some instances by state action. Healy is examining experience with state land use planning now under way in Vermont, and under the California coastal zone initiative. He is taking briefer looks at industrial siting controls in Maine and Delaware, state zoning in Hawaii, and control of private lands in Adirondack Park. From these case studies he hopes to get a better understanding of the problems to which land use planning is directed, how effective it has been, what interest groups have been aroused, and what unanticipated side effects were encountered. This will permit a more general discussion of the criteria for land use planning that will be required if prospective federal legislation is enacted. Next year we expect to broaden the initial effort to include attention to the relation between federal pollution abatement laws and land use controls.

A second study under way is a review of issues in forest policy being undertaken by Marion Clawson. The nation's forests have been subjected to increasing pressures. Demand for wood products, both domestic and foreign, has boomed even while environmentalist and recreational groups have resisted cutting or have proposed restrictions on management practices. Both of these contending forces represent legitimate social interests, but it is not certain that the clash between them need be as severe as it sometimes appears to be. Clawson, who has recently served on a Presidential Commission to examine forest policy, will be drawing upon and revising the work done for that group.

Population Studies

Much of the work this past year has involved follow up activities to the report on "Resource and Environmental Consequences of Population Growth in the United States." Many of the pollution coefficients utilized in that project have been revised and updated, and the energy sector of the model elaborated. In addition, plans were laid for an intensive elaboration and extension of that effort, one which will consider additional environmental and other consequences of changes in population size and distribution. This work should be in full swing by the first of the year.

Plans to extend this project to other countries have also progressed. The director of the studies, Ronald Ridker, spent a week with the Operations Research Group in Baroda, India, helping it start its project. Discussions were also held on starting a similar project in Indonesia. By the end of the coming year we hope to add studies of two other countries.

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Plans have also been made to develop a collection of essays on socioeconomic determinants of fertility that might be amenable to policy influence. These essays will focus on the development of practical policy packages which can be tested out in field experiments, and on the analytical and statistical problems involved in doing so.

The No-Growth Society

The grant made in November 1971 to the American Academy of Arts and Sciences for the purpose of preparing an issue of *Daedalus* dealing with the characteristics, problems, and desirability of a "no-growth" society bore full fruit in mid-September with the publication of the Fall 1973 issue of the journal. The collection of essays, begun in early 1972, was greatly strengthened during the year by the commissioning of additional papers in the fields of both population and economics. This occurred largely as the result of a conference held under joint Academy–RFF sponsorship in October 1972, attended by the majority of the authors, a number of specially invited discussants, and participants from the two organizations sponsoring the undertaking. The issue contains the following essays:

"Introduction," by Mancur Olson
"Zero Population Growth: The Goal and the Means," by Kingsley Davis
"Population and the American Predicament: The Case Against Complacency," by John P. Holdren
"Two Cheers for ZPG," by Norman B. Ryder
"Ills, Bads, and Disamenities: The Wages of Growth," by E. J. Mishan
"The Shadow of the Stationary State," by Kenneth E. Boulding
"The Risks of Growth," by Richard Zeckhauser
"On Reforming Economic Growth," by Marc J. Roberts
"The Technology of Zero Growth," by Harvey Brooks
"Rich Countries and Poor in a Finite, Interdependent World," by Lester Brown
"Should the Poor Buy No Growth?" by Willard R. Johnson
"Urban Zero Population Growth," by William Alonso
"Growth vs. No Growth: An Evaluation," by Roland N. McKean
"Epilogue," by Mancur Olson, Hans H. Landsberg, and Joseph L. Fisher

RFF Fellowship Program

During this — the thirteenth — year in which RFF has conducted its resources fellowship program, twelve fellowships were awarded to doctoral candidates whose dissertations will involve the application of the social sciences to natural resource problems:

Marc Landy, Harvard University — The politics of natural resource regulation: the control of strip mining in Kentucky

Lawrence W. Abrams, Washington University — Operational use of corrective taxes for pollution control

John W. Duffield, Yale University — Wilderness: a land allocation problem

Alfred Runte, University of California — From wonderlands to wilderness: a century of the national parks idea in the United States, 1872–1972

Keshar M. Bajracharya, State University of New York at Syracuse — Economic management of forests in India

Jon David Harford, Stanford University — A theoretical and empirical examination of the effects of the federal grant program for the construction of waste treatment plants

Thomas H. Hammond, University of California, Berkeley — Organizational structure and political adaptation: the case of state fish and game agencies

Wesley J. Jones, Purdue University — The citizen-designer interface: a multidimensional joint-space approach for the selection and design of outdoor recreational facilities

David Hurd Jackson, University of Washington — The theory of price determination for timber: a maturing asset

Thomas K. Rudel, Yale University — Property law, social organization, and material conditions in society

Roger J. Vaughan, University of Chicago — The costs of air pollution

Kenneth Leathers, Colorado State University — The economics of managing saline irrigation return flows in the Colorado River basin.

Thirteen RFF fellows of previous years presented dissertations to their universities in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

Robert C. Baesemann, University of California — The dynamics of agglomeration

Jared L. Cohon, Massachusetts Institute of Technology — An assessment of multiobjective solution techniques for river basin planning problems

Susan L. Flader, Stanford University — Aldo Leopold and the evolution of an ecological attitude

Edward C. Gray, University of California — Economic analysis of the application of a new technology: the utilization of hot and saline groundwater resources in the Imperial Valley, California

Peter H. P. Ho, Carnegie-Mellon University — Demand analysis for urban riverine recreation

Lowell L. Klessig, University of Wisconsin — Recreational property owners and their institutional alternatives for resource protection: the case of Wisconsin lakes

John Kuiper, Stanford University — Analysis of alternative sequences of hydroelectric power developments

Richard H. Mead, Harvard University — The Astoria problem: a systems analysis of an electric power versus air quality conflict

Alexander L. Morton, Harvard University — Freight demand

Frederick M. Peterson, Princeton University — The theory of exhaustible natural resources: a classical variational approach

Arndt Seifert, Michigan State University — The time price system — its application to the measurement of primary outdoor recreation benefits

George W. Silverthorne, University of California — Optimal production from a seaweed resource

Stephen W. Sorenson, University of Texas — A mathematical theory of coalitions and competition in resource development.

Latin American Program

A NEW PHASE

Much of RFF's work in Latin America, except for Brazil, has dealt with aspects of development and management of water resources. The results of this work have been sufficiently promising to suggest that problems related to water could serve as a central theme to guide our research in the region over the next several years. Moreover, our experience has indicated that the productivity of this effort would be greatly increased if it were designed to engage the active participation of Latin Americans interested in this range of problems, who are likely to have a better sense of the priorities among these problems than any foreigner. Moreover, they have readier access to appropriate government agencies and to the data needed to undertake research in this difficult area.

With these ideas in mind, discussions were held in the course of the year with economists, engineers, and hydrologists in Mexico, Colombia, Chile, and Argentina, to probe the degree of their interest in working with RFF in a joint program of research on problems of water development and management. The response was enthusiastic and at year's end the program had begun. Financed by a two-year grant from the Ford Foundation, it involves the Center for Agricultural Economics at Chapingo, Mexico; the Faculty of Economics, University of the Andes, and the Foundation for Higher Education and Development (FEDESARROLLO) in Colombia; the Department of Planning, University of Chile; and the Department of Agricultural Economics, Catholic University, in Chile. It is hoped that arrangements will also be made for the participation of the Institute of Economics, University of Cuyo, in Argentina.

Each institution will undertake research on a problem of special interest to its own participants, except that the two Chilean groups are working jointly on a single project. A series of four seminars will be held over two years, at which the participants will report

on their own work and discuss work undertaken by others. In addition, each participant will spend several weeks visiting the other institutions in this program where he will give seminars on his own work and familiarize himself in detail with the work of his hosts. It is expected that the results of the research will be published in both Spanish and English, either as monographs, papers in professional journals, or as a collection of essays.

Mexico

RFF's representative in Mexico is William Lord, formerly professor of agricultural economics at the University of Wisconsin. During this program year Lord has been developing a program of research at the Center for Agricultural Economics, National School of Agriculture, at Chapingo. He has focused on the problem of rural poverty in Mexico, which continues to be a major concern. The country has maintained a rate of economic growth in excess of 5 percent per year for several decades and has achieved significant success in stimulating agricultural production as part of this generally good economic performance. Nevertheless, the greater part of the gains in agricultural income have been concentrated in the hands of a relatively small number of farmers favored by large-scale public irrigation projects and with ready access to credit, modern inputs such as fertilizers, pesticides, and farm machinery, and with enough land for efficient deployment of these inputs. The great mass of farmers have not participated in these developments and remain desperately poor.

Since the Mexican government has reaffirmed the problem of rural poverty as one of its principal concerns, Lord and those working with him at Chapingo are studying the root causes of the problem with the goal of providing information useful for development of policies to deal with it. The work is focused for the most part on analysis of a variety of Mexican government programs designed to improve the lot of the rural poor. In addition to supervising much of this work, Lord is actively engaged in the study of irrigation policy in Mexico, particularly its impact on small farmers.

Ronald Cummings (Lord's predecessor in Mexico for RFF), now head of the Department of Resource Economics at the University of Rhode Island, completed revisions of his study of PHLINO, a large-scale project of the Mexican government to transfer surplus waters in the Sinaloa-Fuerte valleys of Mexico several hundred miles up the west coast to supplement declining groundwater supplies in the Costa de Hermosillo irrigation district. Cummings' study is now under review.

A matter of continuing interest in our work in Mexico is the relationship between agricultural and urban development. There is much evidence that the rapid growth of some cities, particularly

in the northwestern part of the country, has been a response to the increase in demand for goods and services generated by rapidly expanding agriculture in the hinterlands of the cities. Studies of this relationship have been completed for the cities of Hermosillo and Obregón in the state of Sonora, and a new study was begun of Mexicali in Baja California. The latter study, financed by a grant from RFF, is being done at Arizona State University under the direction of Jerry Ladman. With the others mentioned above, it will be incorporated in an investigation by Pierre Crosson of the effects of public policy toward agriculture on the rate and pattern of urban growth in Mexico.

A study of water planning in Mexico, undertaken for the World Bank by Cummings, Pierre Crosson, John Hernandez, and Edmundo Flores (the last two acting as consultants) was completed and delivered to its sponsor.

Argentina

Kenneth Frederick completed a two-year assignment for RFF in Argentina in July 1973. Working at the Institute of Economics, University of Cuyo in Mendoza, he undertook research on problems of management of that region's water resources. Agriculture, particularly production of wine grapes, is the economic base of the region, and is wholly dependent on irrigation. Water, therefore, is the key to the present and future development of the region. In recent decades the demand for water has so far exceeded supplies available from the area's rivers that groundwater has come to play a vital role in total water supply. There is no central management of the groundwater, however, which has led to a rate of extraction that is excessive from a social point of view. This tendency has been reinforced by government tax and pricing policies, which encourage an even higher rate of investment in wells and pumping equipment than would otherwise occur. In effect, neither public policies nor farmer behavior adequately take into account the increasing scarcity of water in the Mendoza area.

Frederick's study analyzes the historical pattern of agricultural production and water use in the region, showing how, for a variety of economic, political, and institutional reasons, the shift from a condition of water surplus to water scarcity has not yet been sufficiently recognized by farmers and policy makers. A major goal of the study is to suggest alternative policies to encourage patterns of water use more in accord with the real scarcity of the resource, thus strengthening the long-run viability of the regional economy. At year's end a draft of the study had been completed and was in process of internal review.

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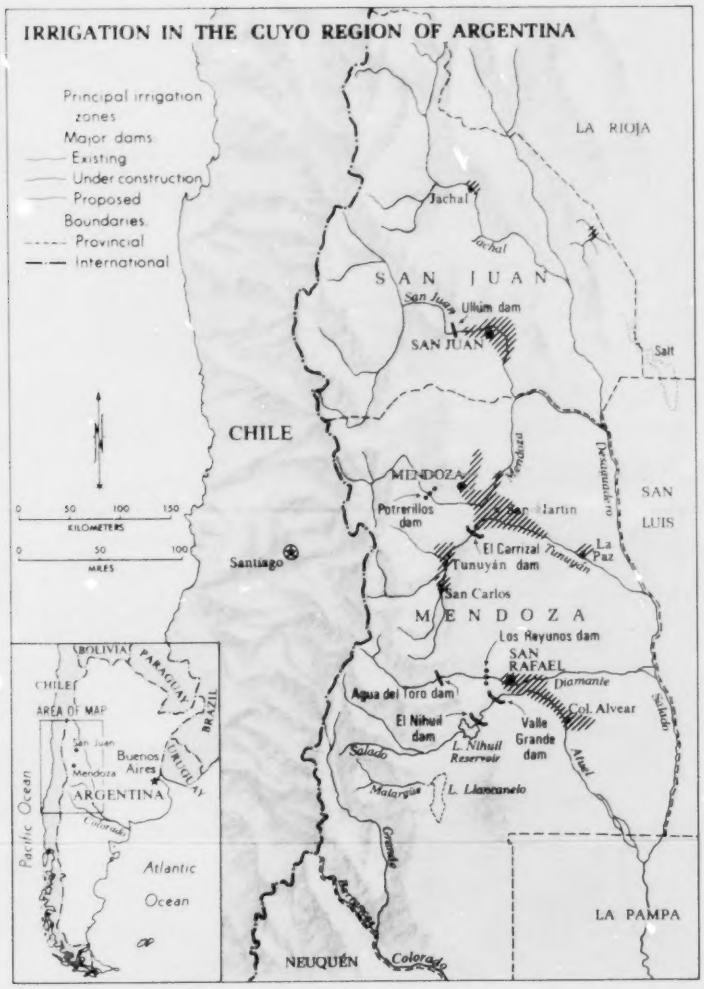

The hatched areas indicate the principal irrigation zones within the Cuyo region of Argentina. Currently, there are nearly 500,000 hectares under irrigation within the region; most of this land is centered around and provides the economic base for the region's three major urban areas—Mendoza, San Juan, and San Rafael. Water use already exceeds the total of the average annual river flows and aquifer recharge, and a continuation of recent rates of increase in water use could exhaust the usable ground water stocks within several decades. To enhance the availability of water, huge investments in dams, lining of canals, and even an interbasin water transfer have been either undertaken in recent years or are under serious consideration. The sites of the major dams are indicated on the map.

Brazil

Arthur Silvers, RFF's representative in Brazil, continued his research and teaching at the Center for Regional Development and Planning (CEDEPLAR), a part of the University of Minas Gerais in Belo Horizonte. Silver's major research project is an analysis of the sources of economic growth in twenty small and medium-size cities in the state of Minas Gerais. His special interest is the effect of public policies, particularly investment in urban infrastructure and in transport facilities linking urban areas, on the competitive position of cities, both in serving local markets and in exporting to markets in other regions. This information would be of value in any government program to affect the pattern of growth in the nation's urban areas, a matter of increasing concern to the Brazilian government. A number of students and faculty at CEDEPLAR are actively engaged with him in the project. Initial processing of data collected in special surveys of various cities was completed, and Silvers began drafting portions of the report during the year.

As part of CEDEPLAR's graduate program, Silvers also taught a course on regional economics and acted as thesis advisor to a number of students. He took the lead in organizing a conference on urban economics and planning, held at the Center in August 1973, sponsored jointly by RFF, CEDEPLAR, and the Ford Foundation, and attended by scholars from five universities in Brazil, by urban planners from a number of government agencies, and by students and faculty of CEDEPLAR. Papers were presented at this conference by Silvers and others, including Lowdon Wingo, formerly director of RFF's urban and regional program and now Chairman of the Department of City and Regional Planning, University of Pennsylvania. After the conference, Silvers and Wingo met with the head and several senior faculty members of CEDEPLAR to discuss how material and ideas developed at the conference could be incorporated into the Center's course structure on urban economics and planning.

Publications

Most of the research done by Resources for the Future takes final shape in the form of books, journal articles, and reprints meant for a readership concerned with natural resources and the quality of the environment, including teachers, research specialists, students, citizen groups, and administators in business, industry, and government.

BOOKS. During the 1972–73 program year, eight new books were published and five others were sent to press; these titles are indicated by an asterisk in the full list of publications below.

Book-length studies published by or for RFF fall into two categories: (1) hardcover books for individual or library use, some of which are also made available as low-priced paperbacks for use as texts or supplementary readings in colleges and universities; and (2) paperbound monographs on more specialized research, reconnaissance studies, and collections of papers presented at conferences sponsored by RFF. Most of the books in the first category are published and distributed for Resources for the Future by The Johns Hopkins University Press and are indicated in the list below as JHUP; the few issued through other publishers are so identified. Books in the second category, which are published by Resources for the Future, are distributed by The Johns Hopkins University Press. They are identified in the list as RFF.

GRANT-SUPPORTED STUDIES published by other institutions. Books based on research supported or partially supported by RFF grants and issued by other publishers during the last five years are listed on pages 123–24.

THE RFF REPRINT SERIES. This series makes available in limited quantities reprints of selected papers written by RFF staff members and originally published in journals or proceedings. Single copies are free on request. Nine new reprints were added during the program year. Reprints available at the close of the year and staff

writings published in professional journals during the year are listed on pages 124–25 and 134–37.

RESOURCES. This bulletin, issued three times a year, contains brief articles based on material from recent books or papers based on staff research. The January issue reviews some significant events of the previous year relating to the use or management of natural resources. The bulletin, which varies in length from four to twenty-four pages, is free on request.

BOOKLETS. The following are available free: a brief description of the organization, *Resources for the Future, Inc.: Its Aims and Work;* a booklet listing RFF fellowship recipients from 1960 to 1973, together with their past and current affiliations; and a list of RFF books in print.

RFF BOOKS STILL IN PRINT

NATURAL RESOURCES AND ECONOMIC DEVELOPMENT

Arrow, Kenneth J., and Mordecai Kurz. *Public Investment, the Rate of Return, and Optimal Fiscal Policy.* JHUP, 1970; third printing 1972. 248 pp. $9.00.

Barnett, Harold J., and Chandler Morse. *Scarcity and Growth: The Economics of Natural Resource Availability.* JHUP, 1963; second printing 1968. 304 pp. $9.00. Paper, 1965; second printing 1969. $2.25. Polish Edition. *Ekonomika zasobow naturalnvch.* Warsaw: Ksiaka i Wiedza, 1967. Zl 30.

Haveman, Robert H. *The Economic Performance of Public Investments: An Ex Post Evaluation of Water Resources Investments.* JHUP, 1972. 142 pp. $7.00.

Haveman, Robert H., and John V. Krutilla. *Unemployment, Idle Capacity, and the Evaluation of Public Expenditures: National and Regional Analyses.* JHUP, 1968. 172 pp. $6.50.

Jarrett, Henry, ed. *Comparisons in Resource Management: Six Notable Programs in Other Countries and Their Possible U.S. Application* — essays based on the RFF Forum lectures of 1961. JHUP, 1961. 292 pp. Cloth out of print. Paper edition (University of Nebraska Press) 1965, $1.65.

†Landsberg, Hans H. *Natural Resources for U.S. Growth: A Look Ahead to the Year 2000.* Based on *Resources in America's Future.* JHUP, 1964; third printing 1967. 270 pp. Paper, $2.45.

Landsberg, Hans H., Leonard L. Fischman, and Joseph L. Fisher. *Resources in America's Future: Patterns of Requirements and Availabilities, 1960–2000.* JHUP, 1963; second printing 1964. 1,038 pp. $20.00. Russian edition. *Resursy S.Sh.A. v budushtshem.* 2 vols. Moscow: Isdatelstvo Progress, 1965, 3r. 57k.

Levin, Harvey J. *The Invisible Resource: Use and Regulation of the Radio Spectrum.* JHUP, 1971. 454 pp. $12.00.

Potter, Neal. *Natural Resource Potentials of the Antarctic.* New York: American Geographical Society, 1969. 106 pp. Paper, $4.00.

Potter, Neal, and Francis T. Christy, Jr. *Trends in Natural Resource Commodities: Statistics of Prices, Output, Consumption, Foreign Trade, and Employment in the United States, 1870–1959.* JHUP, 1962. 580 pp. $17.50.

* Published or in press during the 1972–73 program year.

† Especially prepared for general readers.

Note: RFF and JHUP books in this list may be ordered from The Johns Hopkins University Press, Baltimore, Maryland 21218, or 2-4 Brook Street, London W. 1A, 1AA, England.

ENVIRONMENTAL STUDIES

*Anderson, Frederick R., with Robert H. Daniels. *NEPA in the Courts: A Legal Analysis of the National Environmental Policy Act.* JHUP, 1973. 424 pp. $15.00. Paper, $6.95.

Ayres, Robert U., and Richard P. McKenna. *Alternatives to the Internal Combustion Engine: Impacts on Environmental Quality.* JHUP, 1972; second printing 1973. 340 pp. $12.00.

†Brubaker, Sterling. *To Live on Earth: Man and His Environment in Perspective.* JHUP, 1972; second printing 1973. 218 pp. $6.95. Paper, New American Library (Mentor), 1972. $1.50.

*Frisken, William R. *The Atmospheric Environment.* RFF, 1973. 80 pp. Paper, $3.50.

Goldstein, Jon H. *Competition for Wetlands in the Midwest: An Economic Analysis.* RFF, 1971. 122 pp. Paper, $3.50.

*Haefele, Edwin T. *Representative Government and Environmental Management.* JHUP, 1973. 102 pp. $8.95.

Headley, J. C., and J. N. Lewis. *The Pesticide Problem: An Economic Approach to Public Policy.* RFF, 1967; second printing 1970. 160 pp. Paper, $3.50.

Herfindahl, Orris C., and Allen V. Kneese. *Quality of the Environment: An Economic Approach to Some Problems in Using Land, Water, and Air.* RFF, 1965; fourth printing 1970. 104 pp. Paper, $2.00. Japanese edition. Tokyo: The Tokoro Shoten Publishing Co., Ltd., 1971. 220 pp. 950 Y.

Jarrett, Henry, ed. *Perspectives on Conservation* — essays on America's natural resources based on the RFF Forum lectures of 1958. JHUP, 1958; fourth printing 1968. 272 pp. $9.00. Paper 1969, $2.95.

Jarrett, Henry, ed. *Environmental Quality in a Growing Economy* — essays based on the RFF Forum lectures of 1966. JHUP, 1966; third printing 1970. 190 pp. $7.50. Paper 1971, $1.95.

Kneese, Allen V., Robert U. Ayres, and Ralph C. d'Arge. *Economics and the Environment: A Materials Balance Approach.* RFF, 1970; third printing 1972. 132 pp. Paper, $2.50.

Kneese, Allen V., and Blair T. Bower, eds. *Environmental Quality Analysis: Theory and Method in the Social Sciences.* JHUP, 1972. 420 pp. $12.00.

*Krutilla, John V., ed. *Natural Environments: Studies in Theoretical and Applied Analysis.* JHUP, 1972. 362 pp. $16.50.

*Ridker, Ronald G., ed. *Population, Resources, and the Environment.* Vol. 3 of *Research Reports of the Commission on Population Growth and the American Future.* U.S. Government Printing Office. 380 pp. $4.25, 1972.

*Zupan, Jeffrey M. *The Distribution of Air Quality in the New York Region.* RFF, 1973. 96 pp. Paper, $3.50.

WATER RESOURCES

Bain, Joe S., Richard E. Caves, and Julius Margolis. *Northern California's Water Industry: The Comparative Efficiency of Public Enterprise in Developing a Scarce Natural Resource.* JHUP 1967. 784 pp. $20.00.

Cleary, Edward J. *The ORSANCO Story: Water Quality Management in the Ohio Valley under an Interstate Compact.* JHUP, 1967. 352 pp. $10.00. Paper, $2.95.

Cootner, Paul H., and George O. G. Löf. *Water Demand for Steam Electric Generation: An Economic Projection Model.* RFF, 1965. 156 pp. Paper, $4.00.

Craine, Lyle E. *Water Management Innovations in England.* RFF, 1969. 136 pp. Paper, $3.50.

Davis, Robert K. *The Range of Choice in Water Management: A Study of Dissolved Oxygen in the Potomac Estuary.* JHUP, 1968. 214 pp. $8.00.

Hartman, L. M., and Don Seastone. *Water Transfers: Economic Efficiency and Alternative Institutions.* JHUP, 1970. 144 pp. $5.75.

Haveman, Robert H. See under Natural Resources and Economic Development.

Howe, Charles W., et al. *Inland Waterway Transportation: Studies in Public and Private Management and Investment Decisions.* RFF, 1969. 158 pp. Paper, $5.00.

Howe, Charles W., and K. William Easter. *Interbasin Transfers of Water: Economic Issues and Impacts.* JHUP, 1971. 212 pp. $9.50.

Howe, Charles W., Clifford S. Russell, Robert A. Young, and William J. Vaughan. *Future Water Demands: Impacts of Technological Change, Public Policies, and Changing Market Conditions on Water Use Patterns of Selected Sectors of the U.S. Economy, 1970–1990.* Publication number PB 197 877. National Technical Information Service, U.S. Department of Commerce, Springfield, Va. 22151. 116 pp. Paper (mimeo.), $3.00.

Kneese, Allen V. *Economie et gestion de la qualité des eaux.* Adapted and translated by H. Levy-Lambert. Paris: Dunod, 1967. 37 Fr. (American edition is out of print.)

Kneese, Allen V. *Water Pollution: Economic Aspects and Research Needs.* RFF, 1962; fourth printing 1971. 120 pp. Paper, $1.75.

Kneese, Allen V., and Blair T. Bower. *Managing Water Quality: Economics, Technology, Institutions.* JHUP, 1968; third printing 1973. 338 pp. $10.00. German edition. *Die Wassergütewirtschaft: Wirtschaftstheoretische Grundlagen, Technologies, Institutionen.* München/Wien: R. Oldenbourg Verlag, 1972. DM 68,-.

Kneese, Allen V., and Stephen C. Smith, eds. *Water Research* — 1965 seminars in water resources research (RFF and Western Resources Conference). JHUP, 1967; second printing 1970. 536 pp. $15.00.

Krutilla, John V. *The Columbia River Treaty: The Economics of an International River Basin Development.* JHUP, 1967. 228 pp. $7.50.

Krutilla, John V., and Otto Eckstein. *Multiple Purpose River Development: Studies in Applied Economic Analysis.* JHUP, 1958; third printing 1964. 316 pp. $10.00. Paper 1969, $2.95.

Löf, George O. G., and Allen V. Kneese. *The Economics of Water Utilization in the Beet Sugar Industry.* RFF, 1968. 136 pp. Paper, $4.00.

Russell, Clifford S., David G. Arey, and Robert W. Kates. *Drought and Water Supply: Implications of the Massachusetts Experience for Municipal Planning.* JHUP, 1970. 248 pp. $8.00.

Ruttan, Vernon W. *The Economic Demand for Irrigated Acreage: New Methodology and Some Preliminary Projections, 1954–1980.* JHUP, 1965. 152 pp. $5.00.

Wollman, Nathaniel, and Gilbert W. Bonem. *The Outlook for Water: Quality, Quantity, and National Growth.* JHUP, 1971. 304 pp. (8½" x 11"). $12.00.

MARINE RESOURCES

Christy, Francis T., Jr., and Anthony Scott. *The Common Wealth in Ocean Fisheries: Some Problems of Growth and Economic Allocation.* JHUP, 1966; second printing with new preface, "Since 1965," 1972. 322 pp. $10.00. Spanish edition. *La pesca oceánica: explotación de una riqueza común, algunos problemas de crecimiento y distribución económica.* México, D.F.: Unión Tipográfica Editorial Hispano Americana, 1967.

Crutchfield, James A., and Giulio Pontecorvo. *The Pacific Salmon Fisheries: A Study of Irrational Conservation.* JHUP, 1969. 232 pp. $8.50.

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Clawson, Marion. *The Federal Lands Since 1956: Recent Trends in Use and Management.* RFF, 1967. 128 pp. Paper, $4.00.

Clawson, Marion. *Policy Directions for U.S. Agriculture: Long-Range Choices in Farming and Rural Living.* JHUP, 1968. 416 pp. $12.00. Spanish edition. *Problemas de la producción agrícola.* México, D.F.: Editorial Letras, S.A., 1970.

Clawson, Marion. *Suburban Land Conversion in the United States: An Economic and Governmental Process.* JHUP, 1971; second printing 1972. 424 pp. $12.50.

†Clawson, Marion. *America's Land and Its Uses.* JHUP, 1972. 178 pp. $8.50. Paper, $2.45.

Clawson, Marion, and R. Burnell Held. *The Federal Lands: Their Use and Management.* JHUP, 1957; second printing 1967. 528 pp. $16.50. Paper edition (University of Nebraska Press), 1965, $2.95.

Clawson, Marion, R. Burnell Held, and Charles H. Stoddard. *Land for the Future.* JHUP, 1960; third printing 1968. 592 pp. $16.50.

Clawson, Marion, with Charles L. Stewart. *Land Use Information: A Critical Survey of U.S. Statistics, Including Possibilities for Greater Uniformity.* RFF, 1966; second printing 1969. 422 pp. Paper, $6.00.

Clawson, Marion, and Jack L. Knetsch. *Economics of Outdoor Recreation.* JHUP, 1967; second printing 1969. 348 pp. $10.00. Paper 1971, $2.95.

Clawson, Marion, Hans H. Landsberg, and Lyle T. Alexander. *The Agricultural Potential of the Middle East.* An RFF-Rand study. (New York: American Elsevier) 1971. 336 pp. (8½" x 11"). $19.50.

*Clawson, Marion, and Peter Hall. *Planning and Urban Growth: An Anglo-American Comparison.* JHUP, 1973. 296 pp. $12.50.

*Clawson, Marion, ed. *Modernizing Urban Land Policy.* JHUP, 1973. 256 pp. $11.00.

Clepper, Henry. *Professional Forestry in the United States.* JHUP, 1971. 350 pp. $10.00.

Guthrie, John A., and George R. Armstrong. *Western Forest Industry: An Economic Outlook.* JHUP, 1961. 352 pp. $10.00.

Held, R. Burnell, and Marion Clawson. *Soil Conservation in Perspective.* JHUP, 1965. 358 pp. $11.00. Portuguese edition. *Con-*

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Ise, John. *Our National Park Policy: A Critical History*. JHUP, 1961; second printing 1967. 710 pp. $17.50.

Johnson, Glenn L., and Leroy Quance, eds. *The Overproduction Trap in U.S. Agriculture*. JHUP, 1972. 232 pp. $10.00.

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Morgan, Robert J. *Governing Soil Conservation: Thirty Years of the New Decentralization*. JHUP, 1966. 416 pp. $12.00.

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Zivnuska, John A. *U.S. Timber Resources in a World Economy*. RFF, 1967. 138 pp. Paper, $3.50.

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*Adelman, M.A., *The World Petroleum Market*. JHUP, 1973; second printing 1973. 458 pp. $22.50. Paper, $5.95.

Brooks, David B. *Low-Grade and Nonconventional Sources of Manganese*. RFF, 1966. 136 pp. Paper, $3.00.

Brooks, David B. *Supply and Competition in Minor Metals*. RFF, 1966. 166 pp. Paper, $3.00.

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Brown, Keith C., ed. *Regulation of the Natural Gas Producing Industry*. JHUP, 1972. 272 pp. Paper, $8.50.

Brubaker, Sterling. *Trends in the World Aluminum Industry*. JHUP, 1967. 274 pp. $8.50.

Campbell, Robert W. *The Economics of Soviet Oil and Gas*. JHUP, 1968. 298 pp. $9.50.

*Cicchetti, Charles J. *Alaskan Oil: Alternative Routes and Markets*. RFF, 1972. 160 pp. Paper, $5.00.

Darmstadter, Joel, with Perry D. Teitelbaum and Jaroslav G. Polach. *Energy in the World Economy*. JHUP, 1972. 888 pp. (8½" x 11"). $22.50.

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†McDivitt, James F. *Minerals and Men: An Exploration of the World of Minerals and Its Effect on the World We Live In*. JHUP, 1965; fourth printing 1971. 166 pp. Paper, $1.95. (Revised edition forthcoming.) Spanish edition. *Los minerales y el hombre*. México, D.F.: Editorial Limusa-Wiley, S.A., 1966.

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*Russell, Clifford S. *Residuals Management in Industry: A Case Study of Petroleum Refining*. JHUP, 1973. 210 pp. $11.00.

Schurr, Sam H. *Historical Statistics of Minerals in the United States*. RFF, 1960; second printing 1966. 48 pp. Paper, $1.00.

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Schurr, Sam H., Paul T. Homan, and associates. *Middle Eastern Oil and the Western World: Prospects and Problems.* An RFF-Rand Study. New York: American Elsevier Publishing Company, 1971. 222 pp. (8½" x 11"). $16.00. Japanese translation of Summary and Conclusions. Tokyo: Japan Economic Research Institute, 1971. 4 pp.

Schurr, Sam H., ed. *Energy, Economic Growth, and the Environment.* JHUP, 1972; second printing 1973. 240 pp. $10.00. Paper 1973, $2.95.

URBAN AND REGIONAL STUDIES

Cameron, Gordon C. *Regional Economic Development: The Federal Role.* RFF, 1971. 172 pp. Paper, $4.00.

Dunn, Edgar S., Jr. *Economic and Social Development: A Process of Social Learning.* JHUP, 1971. 344 pp. $10.00.

Heller, Walter W., Richard Ruggles, Lyle C. Fitch, Carl S. Shoup, Harvey E. Brazer. (Harvey S. Perloff and Richard P. Nathan, eds.) *Revenue Sharing and the City.* JHUP, 1968; second printing 1968. 122 pp. $6.00. Paper, $2.50.

Hirsch, Werner Z., ed. *Elements of Regional Accounts* — papers presented at the Conference on Regional Accounts, 1962, sponsored by the Committee on Regional Accounts. JHUP, 1964. 240 pp. $8.50.

Hirsch, Werner Z., ed. *Regional Accounts for Policy Decisions* — papers presented at the Conference on Regional Accounts, 1964, sponsored by the Committee on Regional Accounts. JHUP, 1966. 244 pp. $8.50.

Hochwald, Werner, ed. *Design of Regional Accounts* — papers presented at the Conference on Regional Accounts, 1960, sponsored by the Committee on Regional Accounts. JHUP, 1961; second printing 1969. 302 pp. $8.50.

Keyes, Scott. *Urban and Regional Studies at U.S. Universities.* Compiled and edited by Scott Keyes under the sponsorship of the Bureau of Community Planning, University of Illinois. RFF, 1964. 136 pp. Paper, $2.00.

Margolis, Julius, ed. *The Public Economy of Urban Communities* — papers presented at a 1964 conference sponsored by the Committee on Urban Economics. RFF, 1965; second printing 1969. 282 pp. Paper, $5.00.

Mills, Edwin S. *Studies in the Structure of the Urban Economy.* JHUP, 1972. 166 pp. $7.00.

Neutze, Max. *The Suburban Apartment Boom: Case Study of a Land Use Problem.* RFF, 1968. 184 pp. Paper, $5.00.

Perloff, Harvey S., Edgar S. Dunn, Jr., Eric E. Lampard, and Richard F. Muth. *Regions, Resources, and Economic Growth.* JHUP, 1960. 742 pp. Cloth out of print. Paper edition (University of Nebraska Press) 1965, $2.40.

†Perloff, Harvey S., with Vera W. Dodds. *How a Region Grows: Area Development in the U.S. Economy.* Based on *Regions, Resources, and Economic Growth.* Committee for Economic Development, New York (Supplementary Paper No. 17), 1963. 152 pp. Paper, $2.25.

Perloff, Harvey S., ed. *The Quality of the Urban Environment: Essays on "New Resources" in an Urban Age.* RFF, 1969; third printing 1971. 346 pp. Paper, $6.50. Spanish edition. Barcelona: Oikos-Tau, 1973. 344 pp.

Perloff, Harvey S., and Richard P. Nathan, eds. *Revenue Sharing and the City* (see Heller et al.).

Perloff, Harvey S., and Lowdon Wingo, eds. *Issues in Urban Economics.* JHUP, 1968; third printing 1970. 680 pp. $15.00. Paper, $5.00.

Resources for the Future. *Design for a Worldwide Study of Regional Development.* A report to the United Nations on a proposed research-training program. RFF, 1966; second printing 1967. 92 pp. Paper, $1.50.

Rogers, George W. *Alaska in Transition: The Southeast Region.* JHUP, 1960; second printing 1967. 398 pp. $12.00.

Rogers, George W. *The Future of Alaska: Economic Consequences of Statehood.* JHUP, 1962; second printing 1970. 326 pp. $10.00.

Schaller, Howard G., ed. *Public Expenditure Decisions in the Urban Community*—papers presented at a 1962 conference sponsored by the Committee on Urban Economics. RFF, 1963; fourth printing 1971. 208 pp. Paper, $3.50.

Thompson, Wilbur R. *A Preface to Urban Economics.* JHUP, 1965; second printing 1967. 430 pp. $9.00. Paper 1972, $3.95.

Wingo, Lowdon. *Transportation and Urban Land.* RFF, 1961; fourth printing 1972. 142 pp. Paper, $3.50. Japanese edition. Tokyo:

Kajima Institute Publishing Co., Ltd., 1969. 390 pp. 1700 Y.

Wingo, Lowdon, ed. *Cities and Space: The Future Use of Urban Land* — essays based on the RFF Forum lectures of 1962. JHUP, 1963; fourth printing 1970. 268 pp. $8.00. Paper, 1969, $2.95. Japanese edition. Kajima Institute Publishing Co., Ltd., 1969. 270 pp. 1300 Y.

Wingo, Lowdon, ed. *Metropolitan Governance Series: 1. Reform of Metropolitan Governments* (96 pp.), *2. Minority Perspectives* (76 pp.), *3. Metropolitanization and Public Services* (78 pp.). JHUP, 1972. Paper, $2.25 each. *Forthcoming: 4. Reform as Reorganization* (Spring 1974).

LATIN AMERICAN STUDIES

Crosson, Pierre R. *Agricultural Development and Productivity: Lessons from the Chilean Experience.* JHUP, 1970. 216 pp. $7.00.

Cummings, Ronald. *Water Resource Management in Northern Mexico.* JHUP, 1972. 80 pp. Paper, $3.50.

Grunwald, Joseph, and Philip Musgrove. *Natural Resources in Latin American Development.* JHUP, 1970. 512 pp. (8½" x 11", 248 tables). $20.00.

Herfindahl, Orris C. *Natural Resource Information for Economic Development.* JHUP, 1969. 228 pp. $8.00. Spanish edition. *Los Recursos naturales en el desarrollo económico: medios y programas de información.* Textos del Instituto Latinoamericano de Planificación Económica Social. Santiago, Chile: Editoriail Universitaria, S.A., and México, D.F.: Siglo Veintiuno Editores, S.A., 1970.

Mikesell, Raymond F., and associates (see under Energy and Nonfuel Minerals).

*Nelson, Michael. *The Development of Tropical Lands: Policy Issues in Latin America.* JHUP, 1973. 324 pp. $12.50.

Perloff, Harvey. *Alliance for Progress: A Social Invention in the Making.* JHUP, 1969. 272 pp. $8.50.

Wollman, Nathaniel. *The Water Resources of Chile: An Economic Method for Analyzing a Key Resource in a Nation's Development.* JHUP, 1968. 298 pp. $9.00. Spanish edition. *Los Recursos hidráulicos de Chile.* Cuadernos del Instituto Latinoamericano de Planificación Económica y Social, Series II, No. 10, Santiago, 1969.

STUDIES UNDERTAKEN WITH RFF SUPPORT AND PUBLISHED BY OTHER INSTITUTIONS DURING THE LAST FIVE YEARS

Cameron, Gordon C., and Lowdon Wingo, eds. *Cities, Regions and Public Policy.* Edinburgh: Oliver & Boyd, 1973. 360 pp. £5.00. (Partial support by grant to Conference on Economic Research and National Urban Development Strategies, Glasgow, 1971.)

Cumberland, John H. *Regional Development: Experiences and Prospects in the United States of America.* Regional Planning Series of the United Nations Research Institute for Social Development, Geneva. The Hague: Mouton, 1971. 188 pp.

Duncan, Beverly, and Stanley Lieberson. *Metropolis and Region in Transition.* Beverly Hills: Sage Publications, 1970. 316 pp. $8.95. (Grant to University of Michigan.)

Gerwin, Donald. *Budgeting Public Funds: The Decision Process in an Urban School District.* Madison: University of Wisconsin Press, 1969, 170 pp. $7.50. (Grant to Carnegie-Mellon University.)

Gold, Bela. *Explorations in Managerial Economics.* London: The Macmillan Press, Ltd., 1971. 297 pp. £3.50. (Grant to Case-Western Reserve University.)

Guyol, N.B. *The World Electric Power Industry.* Berkeley: University of California Press, 1969. 386 pp. $20.00. (Grant to University of California, Berkeley.)

Hickey, Richard J., David E. Boyce, Evelyn B. Harner, and Richard C. Clelland. *Exploratory Ecological Studies of Variables Related to Chronic Disease Mortality Rates.* 1971. 194 pp. Paper (Xeroxed). (Grant to Fels Institute of Local and State Government, University of Pennsylvania.)

Hirsch, Werner Z., and Sidney Sonenblum. *Selecting Regional Information for Government Planning and Decision-Making.* New York: Praeger Publishers, 1970. 212 pp. $12.50. (Grant to University of California, Los Angeles.)

Holman, Mary A., and James T. Bennett. *Determinants of Recreational Use at Eight Corps of Engineers Reservoirs in the Dallas–Fort Worth Area.* Washington, D.C.: George

Washington University, 1971. 211 pp. Paper (mimeo.), $4.00. (Grant to Natural Resources Policy Center, George Washington University.)

Isard, Walter, and others. *Ecologic-Economic Analysis for Regional Development.* New York: The Free Press, 1972, 288 pp. $13.95. (Partial support by grant to University of Pennsylvania.)

Klausner, Samuel Z. *On Man and His Environment.* Jossey-Bass Behavioral Science Series. San Francisco: Jossey-Bass, 1971. 238 pp. $8.50. (Grant to Bureau of Social Science Research, Inc.)

MacAvoy, Paul W. *Economic Strategy for Developing Nuclear Breeder Reactors.* Cambridge and London: M.I.T. Press, 1969. 216 pp., $10.00. (Grant to Massachusetts Institute of Technology.)

McCullough, Dale R. *The Tule Elk: Its History, Behavior, and Ecology.* Publications in Zoology, vol. 88. Berkeley and Los Angeles: University of California Press, 1969. 209 pp. $6.50. (Grant to University of California.)

Mack, Ruth P. *Planning on Uncertainty: Decision Making in Business and Government Administration.* New York: John Wiley & Sons, 1971. 256 pp. $11.95. (Grant to the Institute of Public Administration.)

Mennes, L. B. M., Jan Tinbergen, and J. George Waardenburg. *The Element of Space in Development Planning.* Voorburgwal, Amsterdam: The North-Holland Publishing Co., 1969. 340 pp. D. fl. 54 ($15.75). (Grant to Netherlands Economic Institute.)

Ringland, Arthur C. *Conserving Human and Natural Resources.* Berkeley, Calif.: University of California, 1970. 368 pp. Paper (Xeroxed). (Grant to Regional Oral History Office, Bancroft Library, University of California, Berkeley.)

Schnitzer, Martin. *Regional Unemployment and the Relocation of Workers.* Praeger Special Studies in International Economics and Development. New York: Praeger, 1970. 253 pp. $15.00. (Grant to Virginia Polytechnic Institute.)

Smith, Wallace F. *Housing: The Social and Economic Elements.* Berkeley and Los Angeles: University of California Press, 1970. 528 pp $12.95. (Grant to University of California, Berkeley.)

Thomas, Ray. *Aycliffe to Cumbernauld: A Study of Seven New Towns in Their Regions,* vol. 35, broadsheet 516. London: Political and Economic Planning, December 1969. 172 pp. 20s. (Grant to Political and Economic Planning.)

Thomas, Ray. *London's New Towns: A Study of Self-Contained and Balanced Communities,* vol. 35 broadsheet 510. London: Political and Economic Planning, April 1969. 100 pp. 10s. (Grant to Political and Economic Planning.)

RFF REPRINT SERIES STILL AVAILABLE*

10. *Methods of Measuring the Demand for and Value of Outdoor Recreation,* by Marion Clawson. Fourth printing, 1972. Additional copies 60 cents each.

66. *The Lead-Zinc Anomaly,* by David B. Brooks. Reprinted from *Transactions* (Society of Mining Engineers), June 1967.

67. *Conservation Reconsidered,* by John V. Krutilla. Reprinted from *American Economic Review,* September 1967.

75. *Latin American Urbanization: Plan or Process?,* by Lowdon Wingo. Reprinted from *Shaping an Urban Future,* by Bernard J. Frieden and William Nash, M.I.T. Press, 1969.

76. *Production, Consumption, and Externalities,* by Robert U. Ayres and Allen V. Kneese. Reprinted from *American Economic Review,* June 1969.

77. *The Definition and Measurement of Drought Losses: The Northeast Drought of 1962–66,* by Clifford S. Russell. Reprinted from *Proceedings of the Fourth American Water Resources Conference,* 1969.

78. *Desalted Sea Water for Agriculture: Is It Economic?,* by Marion Clawson, Hans H. Landsberg, and Lyle T. Alexander. Reprinted from *Science,* June 6, 1969.

80. *Pervasive External Costs and the Response of Society,* by Allen V. Kneese and Ralph C. d'Arge. Reprinted from *The Analysis and Evaluation of Public Expenditures: The PPB System.* A compendium of papers submitted to the Subcommittee on

* Reprints listed are available from RFF; single copies free on request; additional copies of the same reprint at 25 cents each, except where noted above.

Economy in Government of the Joint Economic Committee, 91 Cong. 1 sess. (1969).

81. *Negotiation and Land Conversion*, by George M. McBride and Marion Clawson. Reprinted from *Journal of the American Institute of Planners*, January 1970.

82. *A New Policy Direction for American Agriculture*, by Marion Clawson. Reprinted from *Journal of Soil and Water Conservation*, vol. 25, no. 1 (1970).

84. *Coalitions, Minority Representation, and Vote-Trading Probabilities*, by Edwin T. Haefele. Reprinted from *Public Choice*, Spring 1970.

85. *The Development of Energy in East Europe*, by J. G. Polach. Reprinted from *Economic Developments in Countries of Eastern Europe*. A compendium of papers submitted to the Subcommittee on Foreign Economic Policy of the Joint Economic Committee, 91 Cong. 2 session (1970). Additional copies 50 cents each.

89. *Middle Eastern Oil in the Next Decade: Some Prospects and Problems*, by Sam H. Schurr. Reprinted from *Proceedings of the Council of Economics*, American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., Annual Meeting, Denver, Colorado, February 15–19, 1970.

93. *Evaluation of an Aspect of Environmental Quality: Heils Canyon Revisited*, by John V. Krutilla. From *Proceedings of the Social Statistics Section, 1970*, American Statistical Association, Washington, D.C., 1971.

94. *A Utility Theory of Government*, by Edwin T. Haefele. From *American Economic Review*, June 1971.

96. *Conservation as Research, Policy, and Action*, by Joseph L. Fisher. The Horace M. Albright Conservation Lectureship no. XI, School of Forestry and Conservation, University of California, Berkeley (April 15, 1971).

98. *Solid Residuals Management: Some Economic Considerations*, by Walter O. Spofford, Jr. From *Natural Resources Journal*, vol. 11 (July 1971).

99. *Economic and Ecological Effects of a Stationary Economy*, by Robert U. Ayres and Allen V. Kneese. From *Annual Review of Ecology and Systematics*, vol. 2 (1971).

100. *Residuals Management in the Pulp and Paper Industry*, by B. T. Bower, George O. G. Löf, and W. M. Hearon. From *Natural Resources Journal*, vol. 11 (October 1971).

101. *Fisheries: Common Property, Open Access, and the Common Heritage*, by Francis T. Christy, Jr. From *Pacem in Maribus*, vol. 2 (University of Malta Press, 1971).

102. *Environmental Quality and International Trade*, by Ralph C. d'Arge and Allen V. Kneese. From *International Organization*, vol. 26, no. 2 (Spring 1972).

103. *Two Studies in Water Resources Management*. "The Temporal Allocation of Ground Water—A Simulation Approach," by John D. Bredehoeft and Robert A. Young; and "Digital Computer Simulation for Solving Management Problems of Conjunctive Groundwater and Surface Water Systems," by Robert A. Young and John D. Bredehoeft. From *Water Resources Research*, vol. 6, no. 1 (February 1970) and vol. 8, no. 3 (June 1972).

104. *The Property Tax Is a Progressive Tax*, by M. Mason Gaffney. From the Proceedings of the Sixty-Fourth Annual Conference on Taxation sponsored by the National Tax Association, 1971.

105. *The Future of Nonmetropolitan America*, by Marion Clawson. From *The American Scholar*, vol. 42, no. 1 (Winter 1972–73).

106. *Resource and Environmental Consequences of Population Growth in the United States . . . A Summary*, by Ronald G. Ridker. From The Commission on Population Growth and the American Future, Research Reports, vol. III (1972).

107. *Environmental Matrix*, by Sterling Brubaker. 1973. Additional copies 10 cents each.

108. *Some Economic and Ecological Considerations Involving Waste Newspapers*, by Thomas H. E. Quimby. 1972. Additional copies $1.00 each.

109. *Congestion, Quality Deterioration, and Optimal Use: Wilderness Recreation in the Spanish Peaks Primitive Area*, by Charles J. Cicchetti and V. Kerry Smith. From *Social Science Research*, vol. 2, no. 1 (March 1973).

110. *Urban Scale and Environmental Quality*, by Irving Hoch. From The Commission on Population Growth and the American Future, Research Reports, vol. III (1972).

111. *Management Science, Economics and Environmental Science*, by Allen V. Kneese. From *Management Science*, vol. 19, no. 10 (June 1973).

Related Staff Activities and Writings

ACTIVITIES -- A SELECTIVE LIST

BLAIR T. BOWER. Continued on the staff of the graduate Department of City and Regional Planning, University of North Carolina, Chapel Hill, as visiting lecturer; served as adjunct professor in the graduate Program in Urban Policy Sciences of the State University of New York, Stony Brook. Was promoted to Fellow, American Society of Civil Engineers. Continued to serve as a member of the editorial board of the *Journal of Soil and Water Conservation* and of the National Advisory Council of the *Natural Resources Journal*. Served as vice-chairman of the Effluent Standards and Water Quality Information Advisory Committee, established under the Water Pollution Control Act Amendments of 1972 to advise the EPA Administrator; member of the American Society of Civil Engineers Committee on Environmental Quality Management; and member of the Water Program Committee of the Environmental Defense Fund. Served as consultant on environmental quality and/or water resources management to: Maryland Environmental Service; UN Water Resources Section; Indiana University School of Public and Environmental Affairs; Johns Hopkins University-Urbanisticni Institut SRS Environmental Project, Ljubljana, Yugoslavia; and the World Health Organization (WHO) Regional Office for Europe. Was WHO consultant to the Czechoslovak Research and Development Centre for Environmental Pollution Control, Bratislava, Czechoslovakia, and served as the WHO consultant on the Mission for Mid-Project Review of the Centre's activities. Spent six weeks as consultant to the firm of Basler und Hofmann, Ingenieure und Planer, Zürich, Switzerland. Presented the following lectures and talks: "National goals for water quality management," to the Water Resources Seminar at North Carolina State University, Raleigh-University of North Carolina, Chapel Hill; "Conceptual framework and mathematical techniques for analysis of residuals-environmental quality management problems" (with Walter O. Spofford, Jr.), in Bratislava and Prague, Czechoslovakia, under the aegis of the Czechoslovak Research and Development Centre for Environmental Pollution Control; "Politics of pollution," at the Indiana University School of Public and Environmental Affairs; "Some comments on the draft report of the national water commission," at the annual meeting of the American Society of Civil Engineers, in Washington, D.C.; "Residuals management in modern society," to the Philadelphia Society for Promotion of Agriculture; "Residuals management in the coal-electric energy industry," to a National Academy of Science panel; "Economics in water quality planning," at the Water Quality Planning Seminar of the Interstate Commission on the Potomac River Basin; "Residuals-environmental quality management: application to Ljubljana," at a public meeting at the U.S. Information Agency in Ljubljana, Yugloslavia; and "Effluent standards vs. effluent charges," at the Swiss Federal Institute for Water Resources and Water Pollution Control. Presented a paper, "Studies of residuals management in industry," at the RFF—Universities-National Bureau Committee for Economic Research Conference on Economics of the Environment, Chicago.

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FRANCIS T. CHRISTY, JR. Continued to serve as member of executive committee, Law of the Sea Institute; Law of the Sea Panel, American Society of International Law; Commission to Study the Organization of Peace; International Marine Science Affairs Policy Committee, Ocean Affairs Board, National Academy of Sciences; Advisory Council, Ocean Studies Program, Woodrow Wilson International Center for Scholars; Advisory Panel for Sea Grant Projects, National Oceanic and Atmospheric Administration; and Economic Potential Committee, Marine Technology Society. Served as associate editor, *Ocean Development and International Law Journal*. Gave papers on fisheries at conference of American Association for the Advancement of Science; and at fourth annual *Pacem in Maribus* conference in Malta. Presented preliminary paper at conference of Asian-African Legal Consultative Committee in New Delhi. Addressed Indian Society of International Law, New Delhi; and gave radio interviews in New Delhi, Malta, and Washington (WAMU-FM). Attended FAO Technical Conference on Fishery Management and Development, Vancouver. Gave lectures on international fisheries, George Washington University Law School and Sidwell Friends School. Was member of panel on the Management of Commercial Fisheries at the Ocean Resources Management Program, Arden House. Gave seminar on ocean resources at the Marine Management Workshop of the Center for Technology and Administration, American University. Participated as judge in the semifinals of the Jessup International Moot Court Competition, Washington, D.C. Organized series of seminars on fisheries at UN Sea-Bed Committee meetings in Geneva (see p. 106).

MARION CLAWSON. Continued to serve as a member of the President's Advisory Panel on Timber and the Environment, and the Committee on Agricultural Production Efficiency of the National Academy of Sciences-National Research Council (NAS-NRC). Named as member of the Board on Agriculture and Renewable Resources, Commission on Natural Resources, NAS-NRC; and of an American Agricultural Economics Association (AAEA) group preparing a section on "Rural People, Communities and Regions — Economic Problems," as part of the AAEA Post War Literature Survey. Presented talks on "Complexity of environmental solutions — trade-offs," to Environmental Conference for Administrators of Continuing Education, Pennsylvania State University; on land and water conservation, at the quarterly meeting of the Maryland State Division of the Izaak Walton League of America; and on "Some economic bases for forest policy," at a meeting of Western Forest Economists. Presented papers on "A look to the past and a look to the future," at the National Land Use Policy Conference, sponsored by the Soil Conservation Society of America; "Land use control in megalopolis — policies and problems," at Symposium on Property Rights and Land Use Controls, American Association for the Advancement of Science (AAAS) annual meeting; "Multiple land use," at the Third World Conference on Animal Production held in Melbourne, Australia; "Alternate uses of land," at Symposium on Deserts and Arid Lands, National Council for Science and Technology of Mexico-AAAS meeting, Mexico City; "Theory of land use planning," at Pennsylvania Land Policy Conference; and "Future demands for forest land resources and uses," at the 1973 National Convention of the Society of American Foresters.

THOMAS B. COCHRAN. Served as consultant to West Michigan Environmental Action; as member of the National Academy of Sciences' Panel on Strategy for Developing Nuclear Merchant Ships; and as member of the Task Force on Energy Conversion Research and Development of the Federal Power Commission's National Power Survey. Presented speech on "Costs, benefits, and alternatives in the AEC's NEPA process: a view from the outside," before the American Law Institute and American Bar Association Course of Study, Atomic Energy Licensing and Regulation — IV, Washington, D.C.

PIERRE R. CROSSON. Served as discussant at a conference on the economics of small farmer agriculture, Purdue University; gave a paper at the International Symposium on Water Resources Planning, Mexico City; participated in a conference on Policies Concerning Migration, Urbanization and Population Distribution in Latin America, held in Bogotá; and served as member of advisory committee on Inter-American Development Bank study of irrigation projects in Latin America.

JOEL DARMSTADTER. Served as a consultant to the Overseas Development Council, Washington, D.C.; as panelist on "The Economics of Energy," Joint Study Group on Military Resource Allocation Methodology, sponsored by the MITRE Corporation; as discussant at the Lehigh University symposium on "The Problems of Economic Growth"; and on a project review panel of the National Science Foundation. Testified (jointly with Milton F. Searl) before the Senate Committee on Foreign Relations at its hearings on energy and foreign policy. Continued to serve as a member of the Johns Hopkins University advisory panel, studying power plant siting in the Chesapeake Bay region. Prepared a paper (jointly with Eric Hirst, Oak Ridge National Laboratory) on "Energy conservation research needs," as part of RFF's project on an energy research agenda, sponsored by the National Science Foundation. Presented papers on various economic aspects of energy at: Outlook for Energy Conference, Upper Midwest Council, Minneapolis; Conference on Energy, the Environment and Human Health, sponsored by the American Medical Association's Congress on Environmental Health, Chicago; Environmental Quality Committee of the League of Women Voters of the National Capital Area; and a symposium at the University of Delaware.

ANTHONY C. FISHER. Conducted seminars at State University of New York at Buffalo; University of California at San Diego; University of North Carolina at Chapel Hill; and University of Maryland at College Park. Presented papers on "An economic and econometric model for the valuation of environmental resources with an application to outdoor recreation at Mineral King" (with Charles J. Cicchetti and V. Kerry Smith), at the Econometric Society meeting, Toronto; and on "Valuing long-run ecological consequences and irreversibilities" (with John V. Krutilla), at an Environmental Protection Agency symposium on the use of cost-benefit analysis in environmental management.

JOSEPH L. FISHER. Accepted membership on the newly formed Advisory Council of the Electric Power Research Institute. Served as member of the Committee on Public Engineering Policy and the Commission on Education of the National Academy of Engineering; the Ocean Affairs Board of the National Academy of Sciences; the Board of Directors of the American Forestry Association; the Arctic Development and Environment Program of the Arctic Institute of North America; the Natural Resources Committee of the U.S. Chamber of Commerce; the Advisory Board of the Ford Foundation's Energy Policy Project; and other resource-related organizations. Attended the annual meeting of the American Association for the Advancement of Science and acted as chairman of a session on "An Evaluation of Forrester-Type Growth Models." At American Public Works Association annual meeting was discussant and invited member of panel on "New Perspectives on Resources and Productivity." Attended conference on the No-Growth Society sponsored by *Daedalus*, the journal of the American Academy of Arts and Sciences, and RFF, at Brookline, Mass., and acted as discussant on the paper by William Alonso entitled "Urban zero population growth." Served as a hearing officer for tenth annual meeting of the D.C. Public Health Association. Participated in the Symposium on Population, Resources and Environment, in Stockholm, organized by the United Nations in cooperation with the Swedish government, where he prepared a paper on "Environmental problems of the developed countries"; in the Second Environmental Leaders' Forum held at Cornell University, where he spoke on "Short-run gains vs. long-run concerns"; and in a conference on Population Problems and Policies in Economically Advanced Countries, held at the Ditchley Foundation, Oxfordshire, England, where he gave an informal talk on changes of policy and governmental action needed to conserve resources and to protect the environment. Was guest speaker on "Resource planning" in the Distinguished Lecture Series at Tulane University; and on "Research, policy, and action for conservation," at the Canadian Pulp and Paper Association in Montreal. Was the banquet speaker on "The challenge of the future — opportunities and imperatives for economic education," at the 25th anniversary celebration of the Kazanjian Foundation, held under the auspices of the Connecticut Council on Economic Education in Hartford. Was invited luncheon speaker on "Energy, environment, and the economy," at U.S. Information Agency-sponsored monthly luncheon meeting of Washington area government, foundation,

and private officials active in science and communication overseas. Presented the Gonzalez Distinguished Lecture, on "A view into the future for energy," under the auspices of the Department of Management, University of Texas, Austin. Presented address on "Costs of pollution," to National Conference on Managing the Environment by the Environmental Protection Agency; on "The energy crisis: national policy and potential solution," to the Western Governors' Conference in Oregon; on "Progress report on the Washington, D.C., Metro," at the annual meeting of the American Transportation Association; and on "Resources for future world human needs," at the School of International Service at American University. Presented paper, "Population growth, resource availability and environmental quality" (with Ronald G. Ridker), to the American Economic Association meeting, Toronto. Gave informal address on transportation to the League of Women Voters of the National Capital Area; and on problems of energy and the environment to the law faculty of the University of Denver.

MASON GAFFNEY. Served as consultant to the government of British Columbia. Was discussant at session entitled, "The Economics of Growth," at the Toronto meeting of the American Economics Association.

EDWIN T. HAEFELE. Continued to serve as chairman, Advisory Panel on U.S. Strategy for Developing Nuclear Merchant Ships, Maritime Transport Research Board, National Academy of Sciences. Served as a member of the editorial board, Urban Transportation Fact Book, Motor Vehicle Manufacturers Association. Gave lectures on "Environmental management and collective choice," at State University of New York, Stony Brook; and "Social choice in a regional environmental model," at the University of North Carolina. Presented papers on "Paradox lost" at American Political Science Association Panel on Formal Theory, Washington, D.C.; on "Environmental quality and the optimal jurisdiction" (with Allen V. Kneese), at the Joint Institute on Comparative Urban and Grants Economics, University of Windsor, Ontario; and on "Representative government and environmental quality," at the Seminar on Institutional Arrangements for Planning and Implementing Water Quality Management Decisions, University of Victoria, B.C. Was appointed visiting professor of political science, University of Pennsylvania.

ROBERT G. HEALY. Served as rapporteur for RFF-Congressional Seminar on National Urban Growth Policy. Lectured on "Theories of urban growth" to an economics class at Virginia Polytechnic Institute, Reston. Coauthored paper, "An economic revision of central place theory," presented at the annual meeting of the Western Economic Association.

IRVING HOCH. Continued to serve as member of Committee on Taxation, Finance and Pricing of the Highway Research Board, National Academy of Sciences. Also continued as associate of the Committee on International Exchange of Persons (Senior Fulbright-Hays Program) and as member of its advisory committee for Western Europe, and served on review panel for NATO awards. Served as consultant to Division of Social Systems and Human Resources, National Science Foundation; as member of editorial board, *Journal of Urban Economics*; as member of standing subcommittee of National Committee on Tunneling Technology, National Academy of Engineering; as participant in Climatic Impact Assessment Program, conference held at Santa Monica, Calif.; as discussant of papers presented on Price-Subsidy Issues in Urban Transportation, Highway Research Meeting; and as project leader in organizing and writing RFF report for U.S. Department of Housing and Urban Development on the relations between natural resources and patterns of urban-regional development. Presented paper on "Rent, transportation and urban scale," at 1973 Washington Operations Research Council Symposium on Urban Growth and Development, jointly sponsored by the Council and the Urban Institute; and lectured on "Quality of life and urban scale," at Seminar on Policy and Analytical Implications of the Quality of Life, University of Pennsylvania, Department of City and Regional Planning. Prepared papers on "Economic trends and demand for the development of underground space," at Engineering Foundation Conference on Need for National Policy for the Use of Underground Space, South Berwick, Me.; and on "Analyzing spatial variations in farm income distributions: a multivariate approach" (with Gary Elsner),

presented at annual meeting of Western Regional Science Association, Monterey, Calif.

ROBERT A. KELLY. Served as member of site visit team to the University of Michigan for the Sea Grant Program of the National Oceanic and Atmospheric Administration (NOAA) and as adviser to the Marine Ecosystem Analysis Program of the NOAA. Attended (with Allen V. Kneese and Walter O. Spofford, Jr.) a seminar at the Office of Management and Budget to consult with staff on program evaluation of the Environmental Protection Agency. Presented paper on "Potentials of systems analysis in evaluation of aquatic environmental impacts," at the American Association for the Advancement of Science Symposium on the National Environmental Policy Act — At the Interface of Law and Environmental Science, Washington, D.C.; and on "Conceptual ecological model of Delaware Estuary," at the Symposium on Systems Ecology: The Modeling and Analysis of Ecosystems, Athens, Ga. Prepared paper on "Operational problems in large-scale residuals management models" (with Clifford S. Russell and Walter O. Spofford, Jr.), for presentation at the RFF—Universities-National Bureau Committee for Economic Research Conference on Economics of the Environment, Chicago.

ALLEN V. KNEESE. Chaired the session of Problems of Theory and Action and presented a paper, "Congressional performance: a case study of national water pollution control legislation in the post-World War II period," at the Public Choice Society's Conference on Social Choice and Political Activism, jointly sponsored by RFF and the Public Interest Economics Foundation at the University of Maryland, College Park. Chaired session at Conference on Evaluation of Federal Environmental Programs sponsored by the National Academy of Public Administration and the General Accounting Office, Silver Spring, Md., session on Economics of Pollution at the annual meeting of the American Economic Association, Toronto; session on Ecology and Economics at the Southern Economic Association meeting, Washington, D.C.; and the session on Management of Water Resources in the International Assistance Programs of the 20th International Meeting of the Institute of Management Sciences, Tel Aviv. Served as consultant to the Appalachian Resources Project of the University of Tennessee on strip mining research, Knoxville, Tenn. Attended meetings of the Geosciences Advisory Panel as a consultant of the Los Alamos Scientific Laboratory on the geothermal energy program sponsored by the U.S. Atomic Energy Commission, the National Science Foundation, and RANN (Research Applied to National Needs). Participated as a member of the planning committee for the Conference on Economics of the Environment, Chicago, sponsored by Universities-National Bureau Committee for Economic Research and RFF, and chaired one session. As keynote speaker, presented a paper, "Comments on the report of the National Water Commission," at the annual meeting of the Universities Council on Water Resources, Lubbock, Tex. Participated as member in a panel discussion on "Environmental control: the trade-offs," at the International Industrial Conference, San Francisco; as member of the Research Advisory Board in National Science Foundation meeting on NSF research, Washington, D.C.; as Advisory Council member on the NSF-RANN Delaware Estuary Project, sponsored by Rutgers University, University of Delaware, and Philadelphia Academy of Natural Sciences, to assist directors in forming research program to reduce pollution. Attended Committee for Economic Development (CED) meetings in New York as a member of the Task Force on Liquid Wastes of CED's Subcommittee on Improving the Quality of the Environment and prepared memorandum on "Sources of waterborne residuals." Presented a paper, "Environmental quality and the optimal jurisdiction" (with Edwin T. Haefele), at the Joint Institute on Comparative Urban and Grants Economics, University of Windsor, Ontario. Participated in international conference on Financial Consequences of the Application of the "Polluter Must Pay" Principle in Flood Protection, organized by the West German Department of Interior, Karlsruhe. Attended (with Walter O. Spofford, Jr., and Robert A. Kelly) a seminar at the Office of Management and Budget to consult with staff on program evaluation of the Environmental Protection Agency; the Research Planning Symposium on Complex Use of Water Resources organized by the International Institute for Applied Systems Analysis (IIASA), Baden, Austria; and advisory meetings of the National Academy of Sciences' Foreign Office to discuss the program of the

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IIASA (Austria) and to assist in establishing a mechanism to ensure optimal United States support to the Institute's operations, Washington, D.C. Participated in the National Academy of Sciences' public forum, "How Safe is Safe? The Design of Policy on Drugs and Food Additives," as an informed discussant in the session on cost-benefit analysis in new product development, Washington, D.C.; as a panel member in session on control strategies, concentrating on effluent taxes, resource use charge, and related economic strategies, during the annual meeting of the Pennsylvania Society of Professional Engineers; and in a Symposium on the Control of Auto Emission as an interviewer with other panel members, sponsored by Brown University and carried by WJAR-TV, Providence, R.I. Arranged a briefing and discussion session between RFF quality of the environment staff members and Marine Ecosystems Analysis Program (MESA) staff members of the National Oceanic and Atmospheric Administration (NOAA) on RFF's Delaware River Basin project, to assist NOAA-MESA in their conceptual model of the New York Bight. Addressed the National Economists Club on "Water pollution control," Washington, D.C. Spoke at faculty seminar on analytic methods in public policy, Harvard University; and on economic aspects of water pollution control at the Symposium on Water Pollution and U.S. Public Policy, sponsored by the American Chemical Society, Chicago. Presented a paper, "Costs of water quality improvement, transfer functions and public policy," at the symposium on cost-benefit analysis in environmental management sponsored by EPA, Annapolis; and a paper, "Establishing the scientific, technical and economic basis for coastal zone management" (with Clifford S. Russell), at the Oceans and National Economic Development Conference sponsored by the NOAA, Seattle. Gave a seminar in a political economy course, Johns Hopkins University, Baltimore; and to the Environmental Systems Program group, Department of Economics, Harvard University. Lectured on environmental economics to a faculty seminar, a graduate seminar, and the general public at Technion, Israel Institute of Technology, Haifa; and on "Economic aspects of environmental pollution: implications for resource allocation and growth," "Analysis of economic and other instruments in pollution control policies," and "The American experience in environmental control policies: an economist's view," before high government officials and senior business managers, Safad, Israel.

JOHN V. KRUTILLA. Elected to the Executive Committee of the Board of Trustees of the Environmental Defense Fund; and to the Executive Committee of the Governing Council of the Wilderness Society. Continued serving on the National Air Quality Criteria Advisory Committee of the Environmental Protection Agency (EPA); as an extramural reviewer for the EPA Research and Development Grant Program and as a consultant to the National Science Foundation in a similar capacity. Participated in a workshop on fisheries economics at the University of Wisconsin, sponsored by the Marine Fisheries Service; and in a workshop devoted to management of wilderness areas at the University of Washington, sponsored by the U.S. Forest Service. Presented a paper entitled "Valuing long-run ecological consequences and irreversibilities" (with Anthony C. Fisher), at the Environmental Protection Agency's symposium on the use of cost-benefit analysis in environmental management; and on "A prototype simulation model of a wilderness area (with V. Kerry Smith), at the U.S. Forest Service. Served as a member of a research and curriculum evaluation panel to review the program of the School of Environmental and Resource Management of the State University College of Forestry at Syracuse, N.Y.; and as a member of a committee of the Wildlife Society directed to draft a new North American Wildlife Policy.

HANS H. LANDSBERG. Joined the faculty of the Salzburg (Austria) Seminar in American Studies to participate in the Seminar's second session of 1973, devoted to "Technology, Growth, and Environment." Accepted appointment as rapporteur of the energy utilization section of the Ninth World Energy Conference to be held in Detroit in September 1974. Continued to be associated with various activities of the National Academy of Sciences-National Academy of Engineering (NAS-NAE) as follows: served as member of the executive board and two panels of the Committee on the Survey of Materials Science and Engineering; the executive committee of the International Environmental Programs Committee; the study team on International Determinants

of National Materials Policy (a unit of the Study Committee on Environmental Aspects of a National Materials Policy); the National Materials Advisory Board (NMAB) and its Committee on Technical Aspects of Strategic and Critical Materials; the task force on the role and operation of NMAB; the steering committee on the October 1973 NAS-NAE meeting on National Materials Policy; and presented a review of energy and resource problems at a special meeting discussing UN World Plan of Action for the Application of Science and Technology to Development. Presented findings regarding RFF resource demand projections for 1970 versus actual demand to Harvard University graduate seminar led by Daniel Bell; addressed Washington Society of Friends on outcome of UN Conference on the Human Environment, Stockholm. Presented a paper on "Environmental issues and policies in the United States," at a meeting on Limits to Growth, near Munich, Germany, arranged by the Bavarian Academy of Political Science and the U.S. Information Agency.

R. TALBOT PAGE. Served as consultant to Library of Congress on recycling study and prepared the paper, "Economics of recycling." Testified at EPA hearings on "No Significant Deterioration" of air quality relating to the Clean Air Act. Served as member of the Task Force on Technical Aspects of the Technical Advisory Committee on Conservation of Energy; and on the Advisory Board to Professionals for the Public Interest. Prepared economic analysis of the Interstate Commerce Commission's Environmental Impact Statement on the effect of freight rates on recycling.

PAUL R. PORTNEY. Presented papers on "Cost-benefit analysis and majority rule," at annual meeting of Public Choice Society, College Park, Md.; and on "Voting, cost-benefit analysis and water pollution policy," at an Environmental Protection Agency water pollution symposium, Annapolis.

THOMAS H. E. QUIMBY. Presented paper on recycling used newspapers to a meeting of the directors of the American Newspaper Publishers Association and newsprint manufacturers of the Canadian Pulp and Paper Association in Montreal, and on the design of high-rise apartments to facilitate recycling to the Building Research Institute Conference on Solid Waste Management in Buildings, St. Louis. Consulted with auditors of the U.S. General Accounting Office (GAO) on impediments to the recycling of municipal refuse in connection with GAO review of the Resource Recovery Act of 1970.

RONALD G. RIDKER. Served as consultant to Committee on Public Engineering Policy, National Academy of Engineering, Chairman of Review Panel on National Science Foundation-RANN (Research Applied to National Needs) and author of report of Review Panel on Growth and the Environment; to Aspen Institute, Population Workshop; to U.S. Commission on Population Growth and the American Future; and to Population Division, United Nations, for World Population Year, 1973-1974. Attended Ditchley Foundation conference on Population Problems and Policies in Economically Advanced Countries, served as rapporteur for one session, and was one of authors of final report. Served as rapporteur, UN Symposium on Population Resources and the Environment, Stockholm, and as panelist for International Bank of Reconstruction and Development Population Review meetings. Gave talk before Environmental Seminar of Agency for International Development, "Multidisciplinary considerations in environmental analysis." Presented paper on "Population growth, resource availability, and environmental quality" (with Joseph L. Fisher), at American Economic Association meeting, Toronto; on "Resource and environmental consequences of population growth in the U.S., some policy implications," for Environmental Protection Agency Conference on Alternative Futures; on "Natural resource adequacy and alternative demographic prospects," at the UN Symposium on Population and Development, Cairo; and on "Population growth, economic growth and the environment in the U.S.," at the International Economic Association Conference on the Economic Aspects of Population Growth, Valescure, France. Attended American Association for the Advancement of Science meeting and gave paper "To grow or not to grow: that's not the relevant question," for symposium on Must We Limit Growth?

CLIFFORD S. RUSSELL. Served as consultant to the Institute of Behavioral Science at the University of Colorado, Boulder; and on the

conceptual model phase of Marine Ecosystem Analysis project for the National Oceanic and Atmospheric Administration (NOAA). Appointed associate editor of *Water Resources Research*; and member of the Water Program Committee of the Environmental Defense Fund. Presented seminars at Naval Weapons Laboratory, Dalgren, Va., on regional environmental quality management models; at Trinity College, Hartford, Conn., on RFF's research program and the economics of environmental quality problems; and at University of Pittsburgh on the "Steel industry model." Taught class in environmental quality economics at University of North Carolina, Department of City and Regional Planning, Chapel Hill. Presented papers on "A residuals management model of integrated iron and steel production" (with William J. Vaughan), at the Steel Industry Economics Seminar, sponsored by the American Iron and Steel Institute and Northern Illinois University, DeKalb; on "Establishing the scientific, technical and economic basis for coastal zone management" (with Allen V. Kneese), at a conference on the Oceans and National Economic Development, sponsored by NOAA, Seattle; and on "Operational problems in large-scale residuals management models" (with Walter O. Spofford, Jr., and Robert A. Kelly), at the RFF—Universities-National Bureau Committee for Economic Research Conference on Economics of the Environment, Chicago.

SAM H. SCHURR. Wrote paper on "Minerals trade and international relations" for Brookings Institution project on Future of the International Economic Order, prepared for the Ford Foundation. Coauthored paper (with Milton F. Searl), "An overview of energy supply and demand for the next decade," for 65th annual meeting of American Institute of Chemical Engineers. Participated in seminar on the world petroleum crisis at the Woodrow Wilson School of Public and International Affairs, Princeton University; and in energy seminar at meeting of Professional Journalism Fellows, Stanford University. Gave talks on "The energy situation" at Consumer Journalism Conference at Northwestern University; on "The energy crisis" at Foreign Affairs Executive Seminar, U.S. Department of State; and spoke on energy situation at meeting of Economic Luncheon Group, U.S. Department of Agriculture. Appointed to Aeronautics and Space Engineering Board of the Committee on Alternate Aircraft Fuels, National Academy of Engineering; to international editorial board of *Energy Policy*, a British publication; to editorial advisory board of new U.S. publication, *Energy Systems and Policy*. Appointed as adviser to subcommittee, of the Committee on Economic Development, on Problems and Potentials of Economic Growth: The Energy Problem; and adviser to Lyndon B. Johnson School of Public Affairs, University of Texas, Austin, on energy policy research. Continued to serve as member of Supply Technical Advisory Committee of the National Gas Survey conducted under the auspices of the Federal Power Commission, and as member of the National Academy of Engineering Ad Hoc Committee for the U.S. Bureau of Mines.

MILTON F. SEARL. Served as consultant to National Science Foundation Solar Energy Program; and Los Alamos Scientific Laboratory, Subterrene Advisory Panel. Served as a reviewer for National Science Foundation on Energy Studies proposals under RANN (Research Applied to National Needs) program; and as member of American Physical Society Committee on 1974 Summer Energy Study. Conducted seminar on energy modeling and edited publication of the working papers. Testified (with Joel Darmstadter) on "Growth in U.S. energy import dependence: prospects and options," before Senate Committee on Foreign Relations. Delivered lectures at University of Iowa; Argonne National Laboratory; and Carnegie-Mellon University Alumni Symposium, on "Energy economics." Presented paper on "Alternate paths to oil and gas supply from domestic sources," at 47th Annual Fall Meeting of the Society of Petroleum Engineers of the American Institute of Mining, Metallurgical, and Petroleum Engineers, San Antonio; and on "An overview of energy supply and demand for the next decade" (with Sam Schurr), at the 65th annual meeting of the American Institute of Chemical Engineers, New York.

V. KERRY SMITH. Delivered lectures at Department of Economics, State University of New York, Binghamton; Department of Economics, University of Pittsburgh; Department of Economics, University of Maryland; Econometrics Workshop, Michigan State University;

and Environmental Economics Program, Southern Economics Association, Washington, D.C. Served as invited tutor on multivariate analysis, American Institute for Decision Sciences, New Orleans; and as invited lecturer, Environmental Economics Program, University of California, Riverside. Delivered lectures on "Regression analysis with dichotomous dependent variables" (with Charles J. Cicchetti) and on "An economic and econometric model for the valuation of environmental resources with an application to outdoor recreation at Mineral King" (with Charles J. Cicchetti and Anthony C. Fisher), at the annual meeting of the Econometric Society, Toronto; on "Economic models and recreation planning" (with Charles J. Cicchetti and Anthony C. Fisher), at the 1972 annual meeting of the Operations Research Society, New Orleans; and on "A prototype simulation model of a wilderness area" (with John V. Krutilla), at the U.S. Forest Service.

WALTER O. SPOFFORD, JR. Served as World Health Organization consultant to Czechoslovak Research and Development Centre for Environmental Pollution Control, Bratislava, Czechoslovakia; and as consultant to Environmental Protection Agency on regional environmental quality modeling. Served as member of Panel on Marine Ecosystems Analysis (MESA) of the National Oceanic and Atmospheric Administration (NOAA); member of the Technical Advisory Committee to the Christina Basin Study, University of Delaware, Newark; member of National Science Foundation Site Visit Team to Center for the Environment and Man, Inc., Hartford, Conn.; and member of editorial board of *Journal of Environmental Economics and Management*. Served on faculty, NATO Advanced Study Institute Systems Analysis for Environmental Pollution Control, Baiersbronn, Germany; and participated in Workshop on Computer Modeling and Simulation as an Aid to Decision Making, Washington, D.C., sponsored by The Institute for the Future for the National Science Foundation. Attended (with Allen V. Kneese and Robert A. Kelly) a seminar at the Office of Management and Budget to consult with staff on program evaluation of Environmental Protection Agency. Presented lectures to graduate students in city and regional planning at State University of New York, Stony Brook, on "Environmental models," "Optimization techniques," and "Residuals management models"; on "Conceptual framework and mathematical techniques for analysis of residuals-environmental quality management problems" (with Blair T. Bower), to Czechoslovak Research and Development Centre for Environmental Pollution Control, Bratislava, Czechoslovakia; on "Residuals management in the Delaware Valley" (with Clifford S. Russell and Robert A. Kelly); to a group from Marine Ecosystems Analysis of the NOAA. Presented papers on "Operational problems in large-scale residuals management models" (prepared jointly with Clifford S. Russell and Robert A. Kelly), to joint RFF—Universities-National Bureau Committee for Economic Research Conference on Economics of the Environment, Chicago; and on "Total environmental quality management models," to NATO Advanced Study Institute Systems Analysis for Environmental Pollution Control, Baiersbronn, Germany.

WILLIAM J. VAUGHAN. Presented papers on "Residuals management in the U.S. iron and steel industry" (with Clifford S. Russell), at University of Pittsburgh, Economics Department seminar; and on "A residuals management model of integrated iron and steel production" (with Clifford S. Russell), at American Iron and Steel Institute and Northern Illinois University Steel Industry Economics seminar, De Kalb, Ill.

FREDERICK J. WELLS. Served as an expert witness and submitted testimony concerning electric utility rate structures in the Potomac Electric Power Company rate case, formal case no. 596, before the Public Service Commission of the District of Columbia. Presented a seminar, entitled "Resources for the future: will we have enough?" at the U.S. Civil Service Commission Executive Seminar Center.

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FINANCIAL STATEMENTS

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REPORT OF INDEPENDENT ACCOUNTANTS

To the Board of Directors of
Resources for the Future, Inc.

We have examined the accompanying financial statements (Exhibits I through IV) of Resources for the Future, Inc. at September 30, 1973 and 1972. Our examinations of these statements were made in accordance with generally accepted auditing standards and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

In 1973, the Corporation changed its method of accounting for vacation pay as described in Note 2 to the financial statements.

In our opinion, the accompanying financial statements examined by us present fairly the assets, liabilities and fund balance of Resources for the Future, Inc. at September 30, 1973 and 1972, its income and expenses and source and application of cash for the years then ended, in conformity with generally accepted accounting principles applied on a consistent basis after restatement for the change, with which we concur, referred to in the preceding paragraph.

Price Waterhouse & Co.

Washington, D.C.
October 25, 1973

Exhibit I

RESOURCES FOR THE FUTURE, INC.

STATEMENT OF ASSETS, LIABILITIES AND FUND BALANCE

	September 30 1973	1972*
ASSETS		
Cash	$ 501,277	$ 252,974
Certificates of deposit	1,200,000	700,000
Grants receivable (Exhibit IV)	1,990,882	4,144,498
Other receivables	80,848	58,560
	$3,773,007	$5,156,032
LIABILITIES AND FUND BALANCE		
Grants payable (Exhibit IV)	$ 125,408	$ 160,252
Accounts payable and accrued liabilities	173,862	181,764
	299,270	342,016
Fund balance at beginning of year	4,814,016	5,593,079
Less excess of expense over income for the year (Exhibit II)	1,340,279	779,063
Fund balance at end of year	3,473,737	4,814,016
	$3,773,007	$5,156,032

* Restated for comparative purposes. (Note 2)

Exhibit II

RESOURCES FOR THE FUTURE, INC.

STATEMENT OF INCOME AND EXPENSE

INCOME	*For the Year Ended September 30* 1973	1972*
Grants:		
Ford Foundation	$ 249,716	$ 763,400
Rockefeller Foundation		600,000
National Science Foundation	309,800	
U.S. Department of Housing and Urban Development	12,000	
Edna McConnell Clark Foundation	300,000	
Interest	59,300	41,588
Contracts with United States agencies and international agencies	79,870	67,768
Total income	1,010,686	1,472,756

EXPENSE	*Staff*	*Grants (Exhibit IV)*		
Program:				
Quality of the environment	$ 390,947	$ 738	391,685	519,979
Natural environments	148,753	7,289	156,042	113,952
Land and water	80,852	31,176	112,030	62,173
Regional and urban studies	156,542	(1,415)	155,127	133,899
Energy and minerals	421,888	44,342	466,230	320,003
Resource appraisals	65,224		65,224	67,044
Special projects	173,487	93,833	267,320	255,166
Latin American	184,006	7,763	191,769	260,146
Policy studies	55,031		55,031	36,204
Publications (less $123,298 and $117,820 received from sales of publications in 1973 and 1972, respectively)	143,299		143,299	169,641
	$1,820,029	$ 183,728	2,003,757	1,938,207
Administration:				
Compensation and employee benefits			192,139	171,989
Travel			16,985	14,064
Rent			73,014	74,967
Furniture, supplies and equipment			21,723	13,889
Other administrative			43,347	38,703
			347,208	313,612
Total expense			2,350,965	2,251,819
EXCESS OF EXPENSE OVER INCOME			$1,340,279	$ 779,063

* Restated for comparative purposes. (Note 2)

Exhibit III

RESOURCES FOR THE FUTURE, INC.

STATEMENT OF SOURCE AND APPLICATION OF CASH

	For the Year Ended September 30	
	1973	*1972**
Cash provided by:		
Grants	$3,025,132	$1,750,387
Sale of certificates of deposit — net		100,000
Other income received	139,170	109,356
	3,164,302	1,959,743
Cash applied to:		
Program expense	2,003,757	1,938,207
Administrative expense	347,208	313,612
Purchase of certificates of deposit — net	500,000	
Increase (decrease) in other receivables — net	22,288	(47,712)
Decrease in liabilities — net	42,746	47,052
	2,915,999	2,251,159
Cash increase (decrease) during year	248,303	(291,416)
Cash, beginning of year	252,974	544,390
Cash, end of year	$ 501,277	$ 252,974

* Restated for comparative purposes. (Note 2)

Exhibit IV

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RESOURCES FOR THE FUTURE, INC.

STATEMENT OF GRANTS

FOR THE YEAR ENDED SEPTEMBER 30, 1973

GRANTS RECEIVABLE	*Balance Sept. 30, 1972*	*Grants (Reductions)*	*Payments (Refunds)*	*Balance Sept. 30, 1973*
Ford Foundation:				
General support	$3,200,000		$2,000,000	$1,200,000
Latin American program	209,000	**$ 250,000**	224,000	235,000
Doctoral dissertation fellowships	51,611	**(284)**	51,327	
New York energy study	47,834		47,834	
World fisheries program	83,333		66,668	16,665
Energy policy studies	190,000		190,000	
	3,781,778	**249,716**	2,579,829	1,451,665
Rockefeller Foundation:				
Environmental quality research	362,720		245,897	116,823
National Science Foundation:				
Social science aspects of energy systems		**205,700**	88,650	117,050
Structural change in the regional and urban economies		**104,100**	10,756	93,344
U.S. Department of Housing and Urban Development:				
Resource and population distribution		**12,000**		12,000
The Edna McConnell Clark Foundation:				
Constructing the conceptual/research framework to provide guidance to the efforts of others in environmental management		**300,000**	100,000	200,000
Total grants receivable (Exhibit I)	$4,144,498	**$ 871,516**	$3,025,132	$1,990,882

GRANTS PAYABLE

Quality of the Environment Program

Carnegie-Mellon University				
Air pollution and human health	$ 18,848	**$ 1,000**	$ 18,058	$ 1,790
Cornell University				
Management and control of community noise	1,374	**(1)**	1,373	
Florida, University of				
Management decisions in the agricultural use of pesticides	10,000	**(10,000)**		
Harvard University				
Social choices by local election	10,350			10,350

Exhibit IV (continued)	Balance Sept. 30, 1972	Grants (Reductions)	Payments (Refunds)	Balance Sept. 30, 1973
Quality of the Environment Program (continued)				
Johns Hopkins University				
Extend "materials-energy balance" methodology applied in Yugoslavia to estimate quantities of residuals generated and residuals management costs		**$ 10,000**	$ 10,000	
New Mexico, University of				
Solid waste problem in New Mexico	$ 40,350		40,350	
Toronto, University of				
Public response to air pollution control measures in the United Kingdom	4,500			$ 4,500
Miscellaneous refunds		**(261)**	(261)	
	85,422	**738**	69,520	16,640
Natural Environments Program				
Brown University				
The optimum use of natural areas		**(2,960)**	(2,960)	
State University of New York				
An examination of alternative management strategies		**10,249**		10,249
		7,289	(2,960)	10,249
Land and Water Program				
American University				
Judicializing the urbanization process		**12,777**	12,777	
League of Women Voters Education Fund				
Handbook on eliminating obstacles to low and moderate income housing in suburban areas		**13,801**	13,801	
Minnesota, University of				
A critical study of the U.S. Forest Service	6,609			6,609
Montana, University of				
Study of wildlife	15,550		9,837	5,713
Northwestern University				
Research on administrative responses to 1972 flood crisis in Black Hills of South Dakota		**1,100**	1,100	
Washington and Lee University				
The structure of the market for Southern forest resources		**3,500**	3,500	
	22,159	**31,178**	41,015	12,322
Energy and Minerals Program				
Denver, University of				
Study of issues and alternatives involved in United States and Canadian trade in energy	24,500			24,500

Exhibit IV (continued)	Balance Sept. 30, 1972	Grants (Reductions)	Payments (Refunds)	Balance Sept. 30, 1973
Energy and Minerals Program (continued)				
Pennsylvania State University				
Metal trade patterns		$ 36,814		$ 36,814
Southern Illinois University				
History and analysis of U.S. oil input controls		7,590	$ 7,590	
Miscellaneous refunds		(62)	(62)	
	$ 24,500	44,342	7,528	61,314
Regional and Urban Program				
California, University of				
Conference on regional accounts	2,012		2,012	
Glasgow, University of				
An economic theory of the size of cities	1,415	(1,415)		
Pennsylvania, University of				
Seminar meetings of Committee on Urban Public Economics	5,712		5,712	
	9,139	(1,415)	7,724	
Special Projects				
Alaska, University of				
Study of alternative arrangements for managing international fisheries in the Indian Ocean region		16,000	16,000	
American Academy of Arts and Sciences				
Conference and an issue of *Daedalus* on the meaning and problems of a "no-growth society"	12,362		12,362	
Maryland, University of				
Diverse studies on "quality of life"		15,000		15,000
Rhode Island, University of				
An evaluation of the implications of alternative ocean management schemes for tuna		9,883		9,883
York, University of				
Study of the fisheries of East Central Atlantic	4,000		4,000	
Doctoral dissertation fellowships		52,950	52,950	
	16,362	93,833	85,312	24,883
Latin American Program				
Arizona State University				
Economic change and development of Mexicali Baja California, Mexico region since 1950		7,763	7,763	
Minnesota, University of				
Foreign investment in renewable natural resources	2,670		2,670	
	2,670	7,763	10,433	
Total grants payable (Exhibit I)	$ 160,252	$ 183,728	$ 218,572	$ 125,408

NOTES TO FINANCIAL STATEMENTS SEPTEMBER 30, 1973 AND 1972

Note 1 — Operations

Resources for the Future, Inc. is a nonprofit tax-exempt corporation headquartered in Washington, D.C. It was established in October 1952 with the cooperation of the Ford Foundation. Its purpose is to advance the development, conservation, and use of natural resources and the improvement of the quality of the environment through programs of research and education.

The corporation has customarily received most of its funds under a series of five-year grants from the Ford Foundation. The current grant will expire in September 1974. Negotiations are in progress with the Ford Foundation for renewed funding.

Note 2 — Changes in Accounting Methods

During 1973, the corporation changed its method of accounting for vacation pay from the cash basis to the accrual basis in order to achieve a better matching of expenses with income. Prior years' financial statements have been restated to reflect this change in accounting. The change resulted in an increase in the excess of expense over income for the years ended September 30, 1973 and 1972 of $5,184 and $11,045, respectively. The fund balance at September 30, 1971 has been reduced by the $74,604 effect of this change on prior years.

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